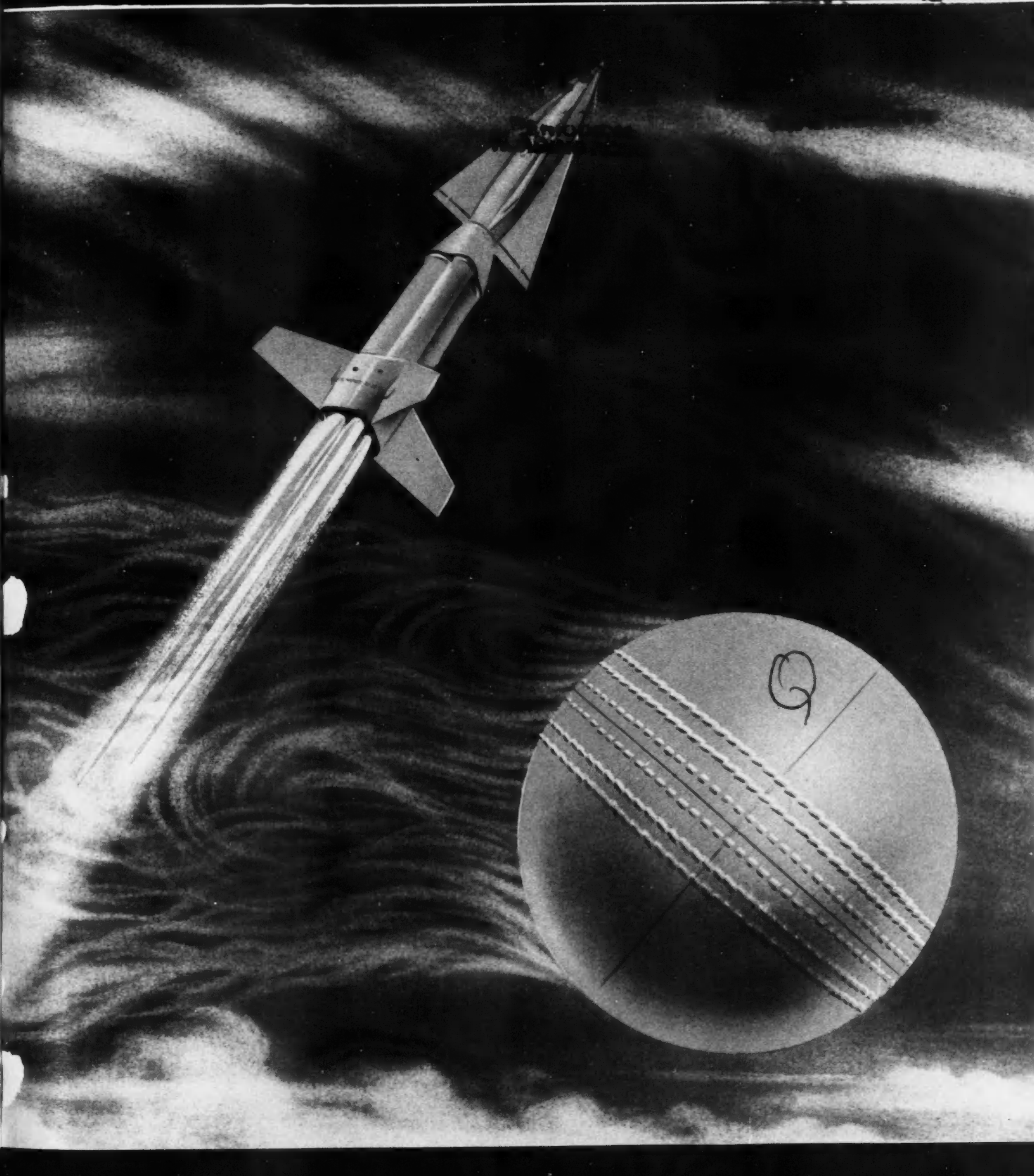
DISCOVERY

MAY 1957 2/6



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Careers in Electricity

This is an extract from a recorded interview with E. O. Maxwell, an established C.E.A. engineer, aged 26.

"...in Power Stations I could get variety and responsibility"

Q.M.: **What first made you come into the Industry?**

Mr. Maxwell: I saw an advertisement for graduate training and it struck me that in power stations I could get the type of experience I wanted—variety and responsibility.

Q.M.: **Any particular reason why you chose this part of the world?**

Mr. Maxwell: Only that my people were living in the South of England so I voted to do my training here.

Q.M.: **After your training . . .?**

Mr. Maxwell: I was appointed Assistant Engineer—plant testing—Croydon B. My first ambition, of course, was to be in charge of a shift.

Q.M.: **Which you were. Weren't you a Charge Engineer before you were 23?**

Mr. Maxwell: Yes. Assistant two years and two months, then Charge Engineer. I was very keen on being responsible for staff and it suited me fine.

Q.M.: **What are your plans now?**

Mr. Maxwell: Well, my plan at the moment is to gain as much experience of the design and construction—construction side mainly—of nuclear power stations. Actually I shall be going, for two years, to one of the Atomic groups in about four weeks' time. My ultimate aim is really to get back into power stations.

Q.M.: **You don't see yourself spending all your time in a nuclear power station?**

Mr. Maxwell: Oh, no. I'm much too young at the moment to specialise. I want to get as much general experience as I can.

We'd like to publish more of this interview, but there isn't space. For details of the many careers in Electricity and the salaried training schemes available, please write to:

The Education and Training Officer,
Central Electricity Authority,
15 Winsley Street,
London, W.1.

CEA

DISCOVERY

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MAY 1957 **VOLUME XVIII** **NUMBER 5**

CONTENTS

COVER PICTURE: This month's cover shows the flight of a cricket ball and the flight of a guided missile. The aerodynamic factors responsible for the swing of a cricket ball are discussed on p. 186, and the use of electronic computers in guided-weapon research on p. 192. The drawing of the guided missile is based on a U.S. Army photograph released in February 1957, showing the *Nike-Hercules*, one of the latest surface-to-air weapons.

THE PROGRESS OF SCIENCE

ARE WE DOING ENOUGH FOR BRITAIN'S FUTURE?

Her Majesty's Stationery Office has recently published, under the title of "Technological Education in Britain",* a very interesting review of the position of technical education in this country and outlined much of the work which is being done, and which it is hoped will be done, in the universities, technical colleges, schools and industry. It is a very useful account of the present-day situation and aspirations, and in its Appendices gives information on this subject in a very ready form.

It seems to base its arguments, however, in the text of the pamphlet, on two points—firstly, that we are not doing as well as Russia and America in technological and technical education; and secondly, that we have neglected this form of education for our pure science.

If we take the second point first, because it leads up to the intrinsic need for even more technological education than the pamphlet suggests, it has been, as Sir Oliver Franks stated in his Reith Lectures in 1954, that "Our traditions are that we recognise the high place of pure science. For centuries men have found enduring satisfaction in exploring the mysteries of nature. But applied science, engineering, the process of industry—no, these are not on the same footing, most useful, no doubt, but not inherently distinguished." He also went on to say that maybe we are right, but we have to live in the same world as others and we cannot afford to ignore them. The figures in the booklet show that we still devote more attention to pure science than to technology, but there is little point in flogging this theme. The point has been well made for some years now and the effects are beginning to be seen in Government action, in interest in the universities and in technical colleges.

The first point, that of comparison with America and Russia, has little value. It does, of course, help to frighten those who are completely ignorant of the situation, but we cannot be content to equal Russia or America. Those two countries have great natural resources, which we have not, and therefore we need additional brain-power to translate what we have into workable tools and valuable finished products. The very fact, as indicated above, that our output of fundamental scientific knowledge is greater than that of America and Russia is in itself proof that we need more technologists than those two countries, in order that we might make every use of our scientific developments.

Still, a great effort is now being made. Whether it is all in the right direction only time can tell, but a warning note might be sounded here. A clear distinction must be made throughout between the training necessary for a technologist and a technician. The former must have a very thorough grounding in the basic sciences, in order to be able to comprehend and use the developments of the pure scientist; the latter, whilst there is need in this technical age of ours for a thorough understanding of the materials and processes with which he is working, is only called upon to carry out intelligently the developments already designed by the technologist.

But when speaking of education, one must also take a much longer view than the next ten years. One cannot be over-impressed by "the bulge". Our industries are already planning for 1977. Plans of nuclear energy plants are dated well into that decade; the petroleum industry and its allied chemical industry is certainly thinking in terms of twenty years hence. Where are the men and women who will be concerned with developments then? What are they being taught at school? They are now mostly in elementary and preparatory schools; how are they being prepared? Are they growing up with an interest in the subjects which will eventually lead us to being the finest technological country in the world?

The raw material is available all right; boys and girls between the ages of five and fifteen are vitally interested in everything and receptive of any information available. Are they being brought up with a love for science? Is their innate interest in how things work and how things grow being developed?—in fact, are they learning to think for themselves? And later on, are they encouraged to understand the systems which govern various countries, or are they put off by inadequate information and stifled by the necessity to pass examinations, which are made as terrifying as possible for them? The answer was given in a debate in the House of Lords on November 21, 1956 (*Hansard*, vol. 200, No. 8). Mathematics, which is the basic essential for coherent thought and for science, is neglected not only in our elementary schools but in the teachers' training colleges which are preparing teachers for these very schools. The Report quoted in the speech in the House of Lords says that in these training colleges arts and crafts are the main study of nine times as many women as mathematics, geography three times as many as mathematics, and history of as many as all the sciences and mathematics put together.

This hardly seems the way to bring up boys and girls who will, in twenty years' time, be expected to take decisions of all sorts—some as scientists, some as technologists, some as managers, and some as, in fact, shop stewards. All of these will need a sense of responsibility, both managers and shop stewards; we repeat, both will have to know how to avoid a misuse of their power. The alternative, unless we are to sink gradually into a nation with a very low standard of living—and we can only really survive through improved production at lower cost, and this means a combination of outstanding technology and hard work—the alternative, if we are to survive at all, will be a dictatorship, in order to direct all forms of effort, and it matters nothing whether the dictatorship is of the Left or of the Right; the result for the individual is the same.

Whilst welcoming, then, every effort that is being made by the universities to become more practical in their approach and the technical colleges, we hope, with their new schemes, to produce technologists of the type required—whilst welcoming all this, we say the interest

* London, H.M.S.O., March 1957, Reference Pamphlet No. 21, 40 pp., 2*s*. 6*d*.

must be carried still further back and every effort, both short-term and long-term, must be made to introduce into the primary and elementary schools that sense of interest in the real world around us that is essential if this country is eventually to produce the numbers of technologists which we shall need.

THE RACE FOR SPACE

Russian scientists gave the first detailed descriptions of the high-altitude experiments they have been carrying out with rockets at a recent conference on jet propulsion at the College of Aeronautics in Paris (December 2–8, 1956). In addition to describing apparatus that had been used to gain physical data at heights of up to 110 kilometres, the Soviet team also spoke of a series of experiments that had been made at similar altitudes with dogs. The outstanding point about the latter experiments was the fact that in later phases the animals were sent up in *unsealed* containers. In many cases the dogs, which were never anaesthetised, were brought down almost the whole of the distance from the peak of the rocket trajectory by parachute. None of them suffered noticeable injury.

In the first of two papers given by members of the Russian team, Dr S. M. Poloskov, of the Academy of Sciences in Moscow, described apparatus that could be used in flights up to 1000 kilometres during the period of the International Geophysical Year (July 1, 1957, to December 31, 1958).

The Russians have on two occasions (Copenhagen in August 1955, and Barcelona in September 1956) stated their intention to launch satellites during the International Geophysical Year, but it was not clear from Dr Poloskov's own lecture whether any of the apparatus he described was intended to be carried in a satellite. A sentence in the original French translation by their own interpreter, which appeared to rule out the satellite because it spoke of the flights being "always at the same high latitudes", was corrected in later copies issued by the delegation and read "also including high latitudes". A satellite launched at high latitudes would, of course, cross into lower latitudes during its circumnavigations of the globe, whereas a rocket would not necessarily do so.

Although the Soviet team behaved in a friendly, if sometimes shy fashion, and answered a number of questions about the various pieces of apparatus and techniques that had been mentioned in the papers, they professed to know absolutely nothing of the vehicles that would carry their instruments aloft or whether satellites would be used.

A detail of the Russian plans which created a good deal of interest among other delegates, and especially among members of the fairly strong British team, was the apparent lack of reliance placed by the Russians on telemetering techniques. Several of them expressed the opinion that not enough was known yet about the transmission difficulties at these altitudes and under such conditions as were expected. Others said that telemetering would be used in further experiments. The fact remained that in all the work that was described, photographic and other recording methods were used to preserve the data which would then be brought down to earth by parachute. The canisters containing the records were claimed to be strong enough to withstand the shock of landing, even if the parachutes failed to open.

As for the storage of apparatus, we were told that each of the rockets carried in the fore part a pair of canisters 2 metres long and 0·4 metre in diameter, weighing 250 kilograms. Each of these canisters is, in turn, made up of two sections, the lower one being hermetically sealed and containing batteries, milli- and micro-ammeters, camera, programming apparatus, clocks and the various electric motors needed for the different devices. The second and upper section, open to the atmosphere, contains manometers, thermometers, and glass globes for the collection of air samples. The parachute for each container is projected by its own sealed container that opens automatically at the appropriate moment.

In all the Russian work the two instrument-containers are expelled by mortars from the rocket near the peak of the trajectory, in order that the measurements may be made well away from any local effects produced by the rocket. Additional mortars are used by the Russians—as they have already been used by scientists of other countries—to expel five smoke-grenades used to measure wind velocities at different altitudes, but the amount of smoke-producing material they contain—5 kilograms in each grenade—is very considerable. The bursts are synchronised so as to obtain practically simultaneous explosion at various heights between 60 and 80 kilometres. Their subsequent behaviour is followed by pairs of cine-theodolites on the ground some dozens of kilometres apart.

The Russians say they have found that the smoke particles, about 0·5 micron in diameter, behave very differently, even between these altitudes. Those at the very high altitudes, above 80 kilometres, fall very quickly and disperse, whereas those released below this level remained aloft much longer. Winds were found to vary a fair amount but were always of a pretty high velocity, about 60 to 100 metres/sec. Their direction, which in summer was east to west, changed in winter to one of from north to south.

In the second Russian lecture, Dr Pokrowsky, who heads a large Aeromedical Research Centre near Moscow, described experiments they had performed which were intended to pave the way for manned flights at altitudes of 100 kilometres. "Flight [by man] in rockets in the upper layers of the atmosphere poses a number of special problems of a technical and medico-biological nature", he said. "Security of flight can only be guaranteed when one has satisfactorily resolved a number of complex questions concerning the maintenance of the vital activity of organisms at high altitude and designed the necessary system to ensure the survival of man." He concluded his lecture, however, by saying that he believed such flights were now possible, but when he was questioned later he would not be drawn into voicing an opinion as to when the next step would be attempted.

The experiments with dogs, Dr Pokrowsky said, were carried out in two stages. In the first of these the animals remained in hermetically sealed containers

throughout the whole of their flight. The volume of each container was 0·28 cubic metre and each included a system for regenerating air, together with apparatus needed for measuring and recording air temperature and pressure, and the conditions of the animal, including temperature, blood pressure, frequency of pulse and respiration. These measurements were supplemented by cardiographs and radiographs taken before and after the flight and by simple tests of conditioned alimentary reflexes.

In the initial tests, nine dogs were used, three of them twice, and they remained sealed in their containers for a total of three hours in each case. The maximum altitude reached was about 100 kilometres, and the highest velocity reached was 1170 metres/sec., with an acceleration that never exceeded 5·5 *g*. Two containers, each carrying one dog, were taken aloft on each flight, the containers being side by side in the nose of the rocket.

During the second phase of the experiments the dogs instead wore a species of space-suit (*scafandre* in the French translation read by the Russian interpreter). This was completely flexible, except for a fixed, spherical headpiece of transparent plastic which permitted films to be taken of the animal during flight. In this phase an independent supply of oxygen was carried. This, with the chassis and measuring and recording instruments, was placed in an unsealed container.

The rest of the procedure in both phases was approximately the same. In each case one of the containers was expelled from the rocket at a height of between 80 and 90 kilometres and allowed to fall freely for 3 seconds before its parachute opened. This brought the animal (still in its container) down from an altitude of between 75 and 85 kilometres in a time of from 50 to 65 minutes. The second dog remained within the rocket, falling freely, until, at a height of 35 to 50 kilometres and a speed of 1000 to 1150 metres/sec., it was, in its turn, catapulted out to continue its free fall separate from the rocket until, at a height of only 3500 to 4000 metres above the ground, its parachute opened automatically.

The experiments permitted the following conclusions to be made, according to Dr Pokrowsky: (1) The space-suits created and maintained the conditions necessary to guarantee survival during rocket flights up to altitudes of more than 100 kilometres, as well as during expulsion from the rocket, descent by parachute from a height of 75 to 85 kilometres, and also in free fall to within 3500 to 4000 metres of the ground; (2) the system of catapulting the animals from the rocket at heights of 75 to 85 kilometres and at speeds of the order of 700 metres/sec. and at heights of 35 to 50 kilometres and speeds of 1000 to 1150 metres/sec. assure the safety of the animals and maintenance of vital activities and the absence of substantial modification of different physiological functions; (3) the system of parachuting assures the complete security of descent and landing of animals equipped with space-suits, from heights of 75 to 85 kilometres; and (4) a flight of short duration, say, one hour, in the upper layers of the atmosphere does not provoke any "brutal" and substantial changes in the behaviour of the animals or in the state and physiological function of their vital organs.

Dr Pokrowsky concludes: "There is no doubt that, thanks to the collective efforts of different branches of science, by representatives of all countries, it will be possible to realise manned space-flights in rockets for the purpose of exploring the upper layers of the atmosphere."

None of the animals died or suffered injury during the experiments.

This latest Russian work indicates that Soviet scientists and engineers, no less than their American rivals, are aiming at an early attempt on space with a manned rocket. Under the Communist hierarchy a project of this sort must remain a matter for the State both to plan and to implement. In the United States, instead, work of this sort has become a field of sharp competition for hard-headed business men who are prepared to add their own companies' money to large subventions received from Service departments. They do this partly for the sake of publicity and prestige and partly, no doubt, because they hope to attract by these baits technical men with imagination to work for them on more down-to-earth projects. Firms like Goodyear, which provided lavishly illustrated brochures of a manned satellite project at the Seventh International Astronautical Symposium in Rome last autumn, are well aware that material of this sort has a far greater chance of bringing their names to the public's attention than reports of improvements that are continually being made to articles of everyday use.

Nevertheless, it would be idle to imagine that motives end there. It is already obvious that, especially in the defence field, aeroplanes of the sort with which we are now familiar, are already on their way out. The battlefield is moving upwards into the rarefied layers of the ionosphere, where no manned aircraft has ever flown and where no piston or air-swallowing motor could function. In these areas the chemical rocket, with its own oxidant, remains supreme and alone. The same types of rockets will be used to establish manned satellites.

The next step—that of achieving manned satellites with all the paraphernalia of "ferries" to take men and materials backwards and forwards—will be a very formidable one. The chief guarantee that it will be attempted is that the Russians, no less than the Americans, know only too well that stations of this sort would have a vital military function. They are a development which cannot be ignored and in which priority of establishment is all-important. Needless to say, projects of this sort involve colossal outlay and commercial orders that no large company could afford to disdain. That most of the American aircraft companies are already alive to this fact is amply demonstrated by attendance at conferences on rocketry, wherever they are held, and most notably by their response to the San Diego Space-travel Symposium held in mid-March this year, which was planned originally by the Convair Division of General Dynamics Corporation as a small technical symposium and developed into the greatest thing of its sort ever to be held in the United States, attended by scientists and engineers representing aircraft, electronic instrument and rocket propulsion companies, the Armed Services, and many universities.

From preliminary reports available so far, it would appear that there were no representatives of the British or the French Services or industries. One can only draw from this the conclusion that, in the race for space, Europe is to be sadly left behind, as it already has been in the development of rockets and guided missiles.

BALLOON-BORNE SOLAR TELESCOPE

The origin of the fine structure of the solar photosphere, or "granulation", has lately become of increasing importance in solar physics because astronomers wish to understand how energy is transported in the outer layers of the Sun. The Sun's surface appears to have a granular structure when seen in good conditions under high magnification; it is not uniformly bright, but possesses very fine white grains on a slightly darker background. Granulation was first photographed by Janssen at Meudon in the 1870's. A measure of the great obstacle to progress which the Earth's atmosphere provides in this study, is given by the fact that Janssen's best plate has not been improved on. Even photographs made with the most advanced modern techniques and after the world has been ransacked for the best locations are not better. Whatever the refinements, the limit of resolution for even the best solar photographs has proved to be no improvement on that taken through an eight-inch telescope.

To overcome these difficulties two Cambridge astronomers, in collaboration with a member of the Meudon Observatory (outside Paris), decided that their observatories must take to the air. If they could take photographs from a balloon floating above the denser and more turbulent layers of the atmosphere perhaps an advance could be made.*

With funds provided by the Royal Society and from French sources, this strange and hazardous balloon flight was made from the terrace of Meudon Observatory on the morning of November 22. It was hazardous as well as strange, because the balloon was manned, was to ascend to heights where oxygen is necessary, and was carrying three-quarters of a ton of very unwieldy load.

The mounting of the apparatus was as follows: An eleven-inch telescope lens, and an optical bench fitted with a Contax camera, were mounted at opposite ends of a twelve-foot welded aluminium frame attached some distance beneath the balloon-basket. This whole telescope assembly was capable of alt-azimuth movement (so enabling it to be guided on the Sun whatever the position of the balloon-basket) and the counterweight for the instrument was provided by twelve six-volt batteries, the power supply. It was essential, of course, that, in focusing, the telescope would rotate in relation to the balloon-basket and not vice versa. This was achieved by ensuring that a large moment-of-inertia bar was fixed to the vertical axis of the telescope mounting. Power leads ran from the camera up to the basket, and these enabled the photography, once all was ready, to be fully automatic. Each opening of the shutter was effected by turning a very small handle in the basket. This was the only movement permitted to the two occupants throughout the two hours that photography was proceeding at 20,000 feet. The shutter was designed to work at 0·8 milliseconds (or at just under a thousandth of a second).

Installing the instrument and launching the balloon was not easy, both because several of the components are extremely delicate and because the telescope mounting projected several feet below the basket. At launching, therefore, the balloon (a standard French type, of 30,000 cubic feet capacity, made of rubberised silk with a lifting capacity of 1650 lb.) was first filled with hydrogen and then tethered by a ring of sandbags so that the bottom was about ten feet from the ground. It was then "walked" to the basket, which had already been made ready, and attached to it. The two astronomers then embarked and the basket was raised by the balloon so that it hung five feet above the ground, where it was held by ropes. While in this position, first the mounting and then the telescope were attached to the basket and the final adjustments made.

Meteorological conditions for such a flight are critical. Launching is only possible when the wind-speed close to the ground is small. There must be a clear sky above 20,000 feet and, preferably, a clear view down to the ground, too. Wind-speed at 20,000 feet is also important, because of the danger of the balloon being carried out to sea "before an unreasonably short time", as one of the astronomers put it.

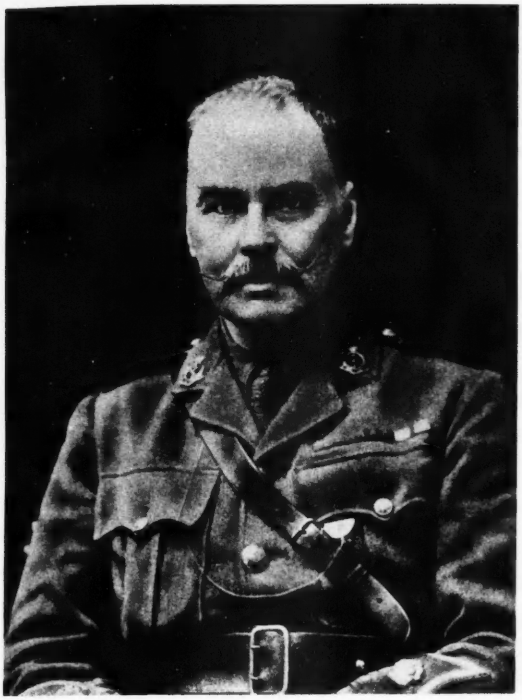
Another awkward period is that when photography is complete and the balloon descends (probably rather fast); then, besides balloon-guidance problems, the key components of the telescope must be retrieved from below with a grappling iron and safely stowed in the basket against the impact of landing, and the rest of the mounting disconnected and dropped by parachute.

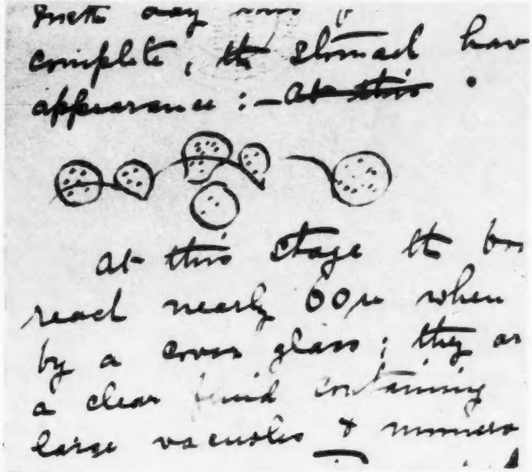
A successful flight—launch, photography, descent—was carried out, however, in November. Three hundred and ninety photographs were taken from a height of 20,000 feet and then safely brought back to earth; so was the precious lens and optical bench, and the two aeronauts. The flight could not be reckoned 100% successful, however, since the cold at height affected the camera mechanism more than had been allowed for, so that the shutter speed was slowed down to half its normal value.

This misfortune reduced the value of the photographs for solar studies, but results were sufficiently good for the method to be abundantly justified. Another flight was made outside Paris this spring with the shutter mechanism adjusted to operate at one three-thousandth-of-a-second. This was expected to remedy the single shortcoming of the previous experiment.

The American astronomer, Dr Martin Schwarzschild, is preparing a comparable balloon-borne study of solar granulation, but it is thought that this will not be ready until the late summer. In this case the balloon will be of the large, fragile polythene variety; and instead of a

* Dr A. Dollfus, the solar astronomer and son of the celebrated French balloonist, M. Charles Dollfus, provided the ballooning experience; Dr D. E. Blackwell (of Cambridge) joined him in operating the apparatus during the balloon flight, and the design and mounting of the instruments was the responsibility of Dr D. W. Dewhirst and Dr D. E. Blackwell.

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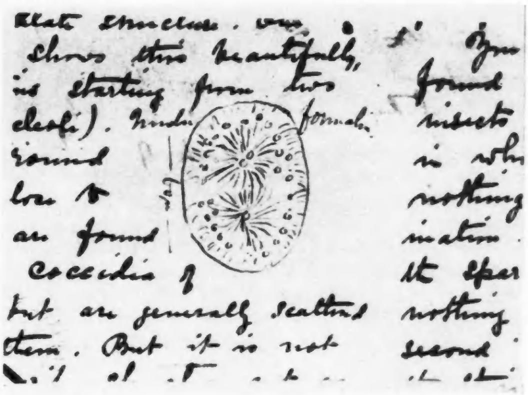
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Above: Sir Ronald Ross, 1857–1932. *Top right:* Letter from Ross to Manson, showing his sketch of oocysts on the stomach wall. *Right:* The mature oocyst. (*Reproduced by courtesy of the Ross Institute of Tropical Hygiene.*)

crew, there will be fully automatic operation, and all the instruments will be considered "expendable". Such an arrangement greatly increases the complication and the expense of the experiment.

SIR RONALD ROSS: MAN VERSUS MALARIA

One of the great scourges of civilisation, malaria in its time has destroyed whole armies, has decimated populations, has wiped kingdoms off the face of the earth. It has killed more men than all the wars of all the ages. Alexander the Great, whose deeds were the wonder of the world, fell a victim to this disease; and the mighty empire which he had created became but a memory to be marvelled at in history. Even today malaria continues to be a bar to progress in many parts of the globe, but its onslaught has become far less deadly since the secret of its transmission has been fathomed. Many men have played their part in this epic story. The centenary of the birth of one of the greatest of these we celebrate on May 13 this year.

The son of an officer in the Indian Army, Ronald Ross was born at Almora, in the Himalayan Kumaon Hills, on May 13, 1857. He was three days old when the Indian Mutiny broke out. Sent to England at the age of eight, in 1874 he entered St Bartholomew's Hospital, London, in deference to his father's wish that he should join the Indian Medical Service. He was interested in so many things that medicine received only a part of his attention, and it was not until he returned to India in 1881 that he became absorbed in health problems. Although he still dabbled in music, literature, and mathematics, his work and environment brought him face to face with mosquitoes. At Bangalore he found that these insects were almost eliminated when he overturned a tub of water outside his quarters, in which they had been breeding. On reporting his observation to the adjutant and suggesting that an extension of this action would lead to a drastic reduction in the mosquito population, he was promptly rebuffed—his first taste of the official attitude to innovation and decisive action. At that time most people looked upon malaria as a kind of exhalation from marshes.

Proceeding on leave in 1888, Ross took the newly established Diploma in Public Health and attended a course in bacteriology. In the following years he worked doggedly at the malaria problem, but failed to find the parasites which had been described by the French army surgeon, Alphonse Laveran, in 1880.

During his next leave, in 1894, Ross met the great Dr (later Sir) Patrick Manson, and was shown various forms of the malarial organism obtained from the blood of a patient in Charing Cross Hospital. He returned to India determined to concentrate on the study of the Plasmodia in the mosquito rather than in the patient. A small microscope of his own invention proved a valuable aid. Often he had to bribe malarial persons before he could obtain specimens of blood, the rate being "a rupee a prick". In an exciting letter to Manson he describes how he watched a free *flagellum* in a drop of blood for three hours without removing his eye from the microscope. Up to June 1897 he was still asking himself which species of mosquito and which kind of parasite held the answer to the riddle of malaria.

Then came the historic day, August 20, 1897. Ross had returned from the hospital to his small laboratory in Calcutta. It was extremely hot and overcast, and he was very tired. His examination of the last *Anopheles* mosquito was almost completed, and he had seen nothing that he had not observed many times before. His eyes half-closed with fatigue, he began to examine the stomach of the insect, when suddenly he realised that he was looking at something new: in its wall he saw clearly outlined circular cells containing black-pigmented granules obviously different from the stomach tissue cells—a great white expanse of cells like a large courtyard of flagstones. These new cells were developing forms (or oocyst) of the fertilised female malaria parasite. He mounted the preparation, returned home, and slept for an hour. On awakening, he knew that the problem was solved. Before, however, he could carry his investigations any further he was ordered on active service. Subsequently, by studying mosquitoes which had bitten birds infected with avian malaria, he was able to prove the mosquito-malaria theory of Manson to be correct. To the Italian Battista Grassi belongs the credit for showing that among the mosquitoes only *Anopheles* transmit malaria.

Manson, who had given so much advice and encouragement to Ross, saw that one further proof was needed. In experiments conducted in endemic areas there was always the possibility that an attack of malaria after mosquito bites might be coincidental. Infected mosquitoes were obtained from Rome, and two volunteers in London—one of them Manson's son—allowed themselves to be bitten. Both developed malaria, and the evidence was complete.

Ross devised drainage systems, reclaimed swamps and sprayed stagnant water with oil to kill larvae by suffocation, protected public buildings, especially hospitals, with wire gauze, and isolated acute cases. It is of interest to note that in 1902, during the widening of the Suez Canal, Ross visited Ismailia and found that anopheline mosquitoes were breeding in great density in pools and marshes formed through seepage or irrigation from the Sweetwater Canal but not in the Suez Canal itself. He recommended that such overflow and seepage should be controlled and that oil should be used as a larvicide where necessary. Within a few years malaria had disappeared from Ismailia.

Ross was awarded the Nobel Prize for Medicine in 1902 and received the K.C.M.G. in 1918. After a long illness he died at the Ross Institute, Putney, on September 16, 1932.

WHEN MOTHS ASSEMBLE

The term "assemble" is used by entomologists in connexion with the mating behaviour of certain moths. It has given rise to considerable speculation, but we now read less about the "mysterious waves" exchanged by male and female moths, and more that is based on accurate observation. In a short note it is impossible to include more than a few details about this intriguing subject, but it is important to mention that the males of some moths devote most of their energy and limited time to finding the females.

The handsome, day-flying emperor moth that haunts moors and other open country is a favourite subject for the experiment of "assembling". The males dash around in the May sunshine in frenzied search for the larger, lethargic females. A dozen or more suitors may arrive in a matter of seconds when a single empress emerges from the pupa, and mating frequently takes place before her wings have dried. The moth collector wanting male emperors rears a female at home, and takes her to a suitable locality in the spring. If conditions are favourable he soon catches all the males he requires. Similar experiments are carried out with the oak eggar, another day-flier, and the attractive Kentish glory.

The fox moth, which flies in the evening during June, provides equal scope. Mr George E. Hyde, who took the photographs here reproduced, says that he had not "assembled" this species until two years ago, but when a female emerged in his breeding-cage, he decided to try. There were no males in sight when he reached the selected place, but within a minute the first one was fluttering round the wire cage containing the "lady", and five more arrived in the next three minutes. No fewer than thirty-seven responded before an hour had passed.

It is natural to wonder by what means the males are guided to the females, for it is this that has caused so much speculation and the publication of exaggerated accounts. The females emit a subtle scent, which is picked up by the sensitive organs of the males, and acts as a lure. The antennae play a large part in this detection, and those belonging to the males are more elaborate than those of the females. The scent cannot be discerned by human beings, but an empty box which has recently contained a virgin female moth is often sufficient to attract male moths. It should be understood that a female attracts males only of her own species. "Assembling" experiments have also been made with various night-flying moths, but the behaviour of many of these is less spectacular than that of the emperor and other day-fliers. A female poplar hawk moth released in George Hyde's garden at dusk attracted at least three males during the dark hours, and on the following morning she remained paired with one of them. Two others were resting close by. It seems certain, however, that there is yet much to learn about the mating behaviour of many different moths that are active only after sundown.

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FIG. 1 (*right*). The female emperor moth is inside the muslin-covered jar. The two males have "assembled". About natural size.

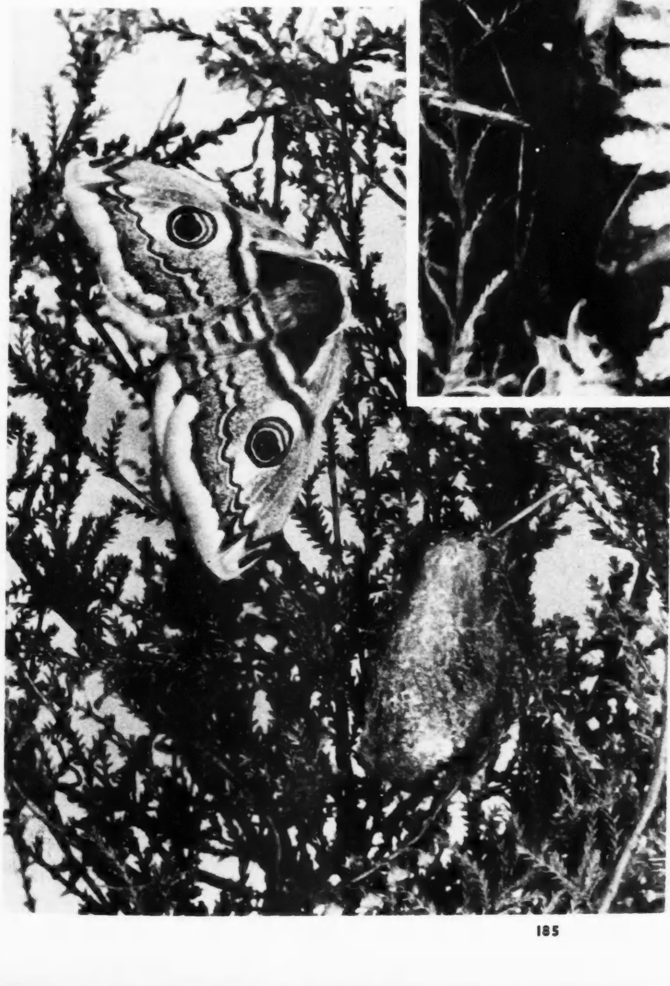


Fig. 2 (*left*). Female emperor moth and cocoon. The pupa is enclosed in the cocoon. Slightly enlarged.

THE SWING OF A CRICKET BALL

R. A. LYTTLETON, F.R.S.

One of the most surprising things in cricket is the phenomenon of "swing bowling", as it is termed. Newton's laws of motion, and indeed ordinary general experience, lead us to expect that the ball, once free, should travel always in the same vertical plane, acted upon only by gravity. But any cricketer knows that on occasion at least this does not hold, and the ball can be bowled in such a way as to make it move out sideways from this expected vertical plane, and swerve in the air. This is what is meant by "swing" bowling, and it is this curious behaviour of the ball in its flight through the air that is the subject of the present article. We are not here concerned with spin effects that can deviate the ball once it strikes the ground.

SWING NOT A RECENT DISCOVERY

In popular discussions swing is often said to have begun with Hirst, the Yorkshire left-arm bowler, at about the turn of the century. But in fact there is plenty of evidence that long before this it was part of the armoury of several bowlers, notably the great Dr W. G. Grace himself, who besides being the prince of batsmen was also one of the very greatest bowlers of all time. Ranjitsinhji in his "Jubilee Book of Cricket" refers to half a dozen players, all much earlier than Hirst, who were able to make the ball "curl in the air", and he adds that "a perfectly new ball seems to favour the peculiar flight". So there is no doubt he was referring to genuine swing. Moreover, a whole century later, Noah Mann, one of the famous Hambledon Men, was able to make the ball "curve the whole way" with his left-hand under-arm deliveries. And it seems only fair to mention America's contribution: that country provided one of the greatest exponents of swerve in the person of a certain J. B. King. Among many sensational feats for the Philadelphians, King once bowled the great Ranji first ball while taking 7 Sussex wickets for a mere 13 runs with his fast swing bowling.

MORE NEW BALLS AVAILABLE LATTERLY

Nevertheless it does seem probable that swing bowling has come much more into vogue during the present century, if only because of the rule permitting the use of the all-important new ball not only at the beginning of the innings but after every 200 runs scored in the innings. This rule was first introduced in 1907. Hitherto a new ball made its appearance only at the start of an innings, and there was therefore not much to encourage a plan of campaign based on successive uses of the new ball. Such planning of new-ball attack was at its height about 1948 when, as the law then stood, a new ball could be introduced every 55 overs, which sometimes meant before even a hundred runs had been scored. The practical effect of the revised rule has been that on the average a new ball is available every 130 runs or so, as a few sample matches will show, instead of after the average length of an innings, which is more like 230 runs.

SPIN NOT THE CAUSE OF SWERVE IN CRICKET

Of course the phenomenon of swerve occurs not only in cricket, but in golf (as slicing and pulling), in tennis, and in baseball, besides a number of other games. But in these it occurs as a result of spin given to the ball, whereas in cricket the ball can be made to swerve without any significant degree of spin being imparted to it. This is because of the presence of the band of seam stitches that runs round the otherwise smooth surface of the ball, separating it into two hemispheres. It is our object to explain the nature of the mechanism by which this seam can operate so as to bring about swing.

Clearly, if cricket were played in a vacuum there would be no swing effects, so the cause must arise from the presence of the air. Despite the negligible mass of air displaced by a ball—about 1/100th of an ounce, compared with its weight of $5\frac{1}{2}$ ounces—the forces exerted by air pressure on the ball are very large. The atmospheric pressure of 15 lb. per sq. inch means that on any two hemispheres of a cricket ball the opposing resultant pressure forces are each about 90 lb. weight. So if by some means a *pressure difference*, as between the left-hand side of the ball and the right-hand side, could be brought about, in which these opposing forces failed to balance by as little as one part in a thousand, a sideways force of about a quarter the weight of the ball would come into action. Such a force could deviate the ball sideways by about a foot if acting for half a second.

THE KINEMATIC CONDITION TO BE SATISFIED AT THE SURFACE OF THE BALL

In order to see how any difference of pressure of this kind could enter, it is necessary to consider in some detail what exactly happens to the air near the ball as the latter travels through it. The air is obviously pushed aside and parted at the front, but it does not simply slide by the ball and join up again at the back in an otherwise undisturbed way. One of the most important physical properties of fluids is here concerned, namely, whenever a fluid such as air streams past any solid surface, the particles of fluid actually in contact with the surface adhere to it, and move always at exactly the same speed as the body itself. This is the boundary condition that differentiates so-called *real* fluids from classical fluids for which only the normal component of velocity vanishes at a solid surface. So in the present case, the air immediately in contact with the ball is moving with it, being at rest on its surface. On the other hand, not very far away, the air quite obviously must be streaming past hardly disturbed at all by the ball moving through it. As a result, this means that on the forward part of the ball at least, where it is breasting its way through the air, there is an extremely thin layer just outside the surface of the ball in which the motion of the air changes from that of the ball itself to almost no movement at all (or, more accurately, to the motion that a classical fluid would have).

For the speeds at which a cricket ball moves, this *boundary layer*, as it is termed, is of a depth of a few hundredths of an inch, but its thickness is least at the very front of the ball and gradually increases round the sides. And it is in fact the behaviour of this boundary layer, in particular the effect of very slight surface roughness of the ball upon it, that provides the key to the explanation of the cause of swing.

THE SPEED OF THE BALL IN FAST BOWLING

Before proceeding it might be as well to say something of the actual speeds that do occur in cricket. Few cricketers appear to have much idea of the speed at which the ball moves in various conditions, and one sees timid batsmen hanging on to their crease as though the ball could be returned from the field with the speed of light. P. F. Warner, in his book on cricket that has seen many editions, states that the fast bowler Kortright bowled at 2000 feet a second, while his rival Cotter is recorded as capable of only 1950 feet per second! No doubt these values correspond accurately with the psychological impression of facing a really fast bowler, but in fact they overestimate possible speeds by considerably more than a factor of ten. The fastest bowlers probably never much exceed about 90 miles per hour, which is roughly 130 feet per second.

EXTENT OF THE BOUNDARY LAYER

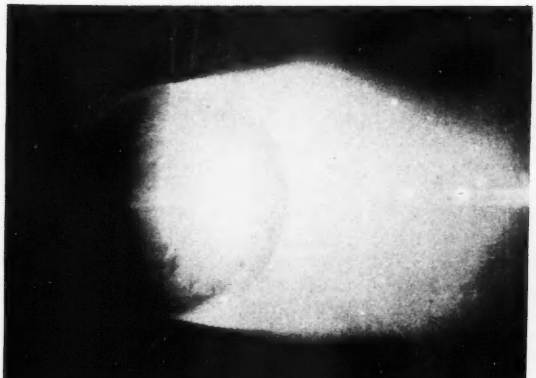
If now the speed of the ball is extremely small, the boundary layer is found to cling to the ball's surface almost round to its rearmost point before the boundary layer finally leaves in a narrow stream. But when the speed approaches the rates that actually occur in cricket conditions change, and the boundary layer breaks away about half-way round the ball at the sides. Immediately behind the ball the air is now violently agitated and forms an irregular eddying wake that gradually diffuses back into the surrounding undisturbed air as it drifts away behind the ball. The outer surface of this conical wake is more or less the continuation of the boundary layer that streams off the sides of the ball. The existence of this turbulent wake can be demonstrated and made visual, in experiments in which the ball is held at rest and the air made to stream past it, by the introduction of smoke into the air. (Fig. 1.)

If now the speed of the ball is steadily increased, the place on the surface where this smooth, laminar, boundary-layer flow ceases, gradually moves *forward* on the ball. But there is a limit beyond which it never goes, not quite half-way round the ball from the front—actually about 80° from the forward stagnation point at the nose of the ball—and the boundary of the eddying wake streams off at a tangent from that part of the ball.

The energy needed to produce the turbulence in this wake comes from that of the ball, which accordingly experiences a resistance slowing it down. It might be thought that resistance would arise mainly from the drag of the air slipping by at the sides, but at the speeds concerned the contribution of this is in fact negligible compared with the effect of the low pressure region of the wake immediately behind the ball. This region, because of the pressure defect in it, acts as a kind of partial vacuum sucking the ball back. In other words the resistance opposing motion arises almost entirely because the pressure on the forward half of the ball is higher than it is on the rear half.

THE ONSET OF A TURBULENT BOUNDARY LAYER

If the speed is still further increased, entirely unexpected effects then come into operation, and it is fundamentally these that account for the phenomenon of swing. The boundary layer begins to creep further round towards the back of the ball again as the (steady) speed is gradually increased, before finally breaking away to form the edge of the wake. But the extension of the boundary layer now no longer involves purely laminar flow parallel to the surface of the ball. Instead, it takes the form of what is known as a *turbulent boundary*



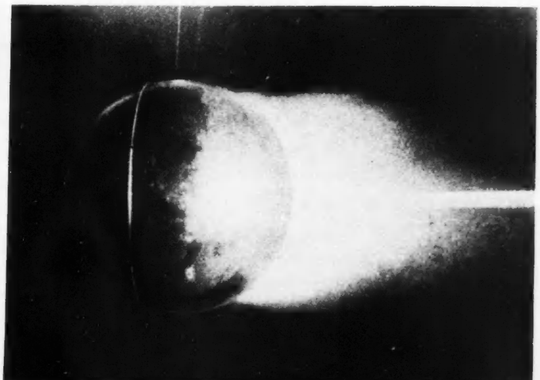


FIG. 1. Smoke photograph of flow past a sphere at an air speed below the critical value.
FIG. 2. Effect on the flow of surface roughness produced by a wire hoop on the forward part of the ball. (Reprinted from the article on "The Generation of Vortices in Fluids of Small Viscosity", the Wilbur Wright Memorial Lecture given in May 1927 to the Royal Aeronautical Society by Dr L. Prandtl. *J. R. aero. Soc.*, 1927, vol. 31, p. 718.)

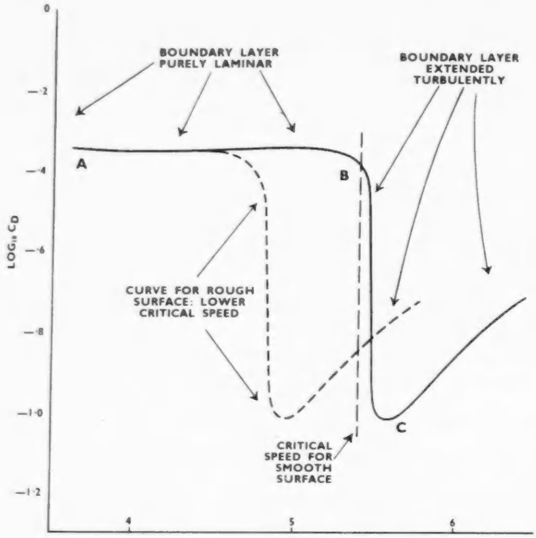


FIG. 3. Curve showing the relation of the drag coefficient C_D to the Reynolds number R. For the part AB the boundary layer is laminar only, but for increase of speed beyond B it begins to extend as a turbulent layer. The dotted curve shows how surface roughness lowers the Reynolds number at which the sudden drop in C_D enters.

layer, wherein although the motion is again practically confined to a shallow depth at the surface, the fluid in it is moving irregularly to and fro across the layer superposed on the general flow along it.

As this turbulent boundary layer extends, with increasing speed of the ball, the place of separation moves towards the rear, and accordingly the low pressure region is contracted to a smaller area on the back of the ball; that is, the initial breadth of the wake is narrowed, and as this proceeds the resistance to the motion begins to decrease quite abruptly and substantially. The range of speed, from the absence of turbulent extension of the boundary layer to the maximum possible extension, is covered by an increase of only about 25%. At the top end and at still greater speeds, the boundary layer reaches to within about 50° of the rearmost point of the ball before breaking away. (Figs. 4, 5.)

THE EXISTENCE OF A CRITICAL SPEED

For any particular size of sphere, there is a "critical speed" at which these things begin to happen, and immediately above which the force of resistance quite suddenly starts to drop rapidly. For an almost perfectly smooth metal sphere the same size as a cricket ball, the boundary layer begins to extend rearwards again (in turbulent form) when the speed rises above about 120 miles per hour. But the precise value of the critical speed is very sensitive to surface roughness, and for a ball possessing even a small degree of roughness, this critical speed may be considerably smaller.

Where cricket balls are concerned, roughness other than that produced by the stitches of the main seam—whose plane for present purposes is to be regarded as kept always fore and aft—will depend on the texture and finish of the leather when new, and also on the various surface markings, such as the golden crown or trade marks that are stamped on the sides of the ball, and even the slight indentations of the hidden lines of stitches that run at right angles to the seam. The degree of roughness involved in these is measured in elevations and depressions of the surface of a few thousandths of an inch. Experiments in which a wire ridge is mounted on the forward part of a circular cylinder in a stream suggest that if the surface roughness amounts to about 2/1000 inch the critical speed is reduced to about 120 feet per sec.; for 4/1000 inch it is lower still at about 90 feet per sec., and for 10/1000 inch it is only about 60 feet per sec.

THE DRAG COEFFICIENT

Theoretically, it is more convenient to use dimensionless numbers applicable to all spheres and speeds, and for this purpose the speed is replaced by the Reynolds number $R = Ud/\nu$. The onset of the critical speed is then demonstrated very clearly by plotting against R the so-called drag coefficient, which is a dimensionless representation of the actual force of resistance. This is denoted by C_D, and is equal to the actual resistance force $\div \frac{1}{8}\rho U^2 \pi d^2$, where ρ is the density of the air, U the air speed, d the diameter of the sphere, and ν the kinematic viscosity. The resulting curve can then apply to spheres of all sizes provided that they are of comparable roughnesses. The logarithmic graph of C_D against R for Reynolds numbers ranging from 10^4 to 2×10^6 is shown in Fig. 3. The actual drop in the drag co-efficient at the critical speed corresponds to a factor of nearly 1/5, and so even allowing for the slight increase of speed across the cliff of the curve a *reduction* in the actual force of resistance by a factor of about 1/4.

EFFECT OF ROUGHNESS ON THE BOUNDARY LAYER

The reason that the critical speed is affected by surface roughness is because increase of speed is not the only way that the boundary layer can be made turbulent and caused to cling further round the ball. For a given size of sphere, this can be achieved at speeds much *less* than the critical speed for a smooth surface by attaching small raised ridges to the otherwise even surface; in other words by introducing roughness at suitable parts of the surface. At first sight, one might think that any such surface irregularity would tend to incite separation of the boundary layer, but in fact experiments show that just the reverse happens. A thin wire ridge placed transversely to the air stream round the front part of the ball, where the boundary layer is laminar, results in the boundary layer, in turbulent form, extending much further round the sphere than it otherwise would for a given air speed before lifting off into the wake. (Fig. 2.)

The effect can be thought of simply as one of roughness lowering the speed at which the critical drop in

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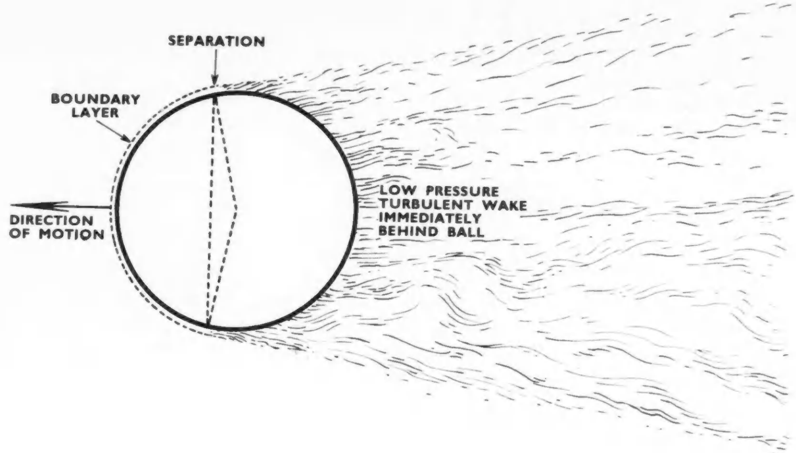


FIG. 4. Symmetrical flow with ball moving below the critical speed. The extent of the boundary layer and the general form of the turbulent wake behind the ball. The wake is slightly broader than the ball, and the pressure in it immediately behind the ball is *lower* than on the front part of the ball. It is the net effect of the pressure on the whole surface that retards the ball. The wake gradually melts back into the undisturbed air.

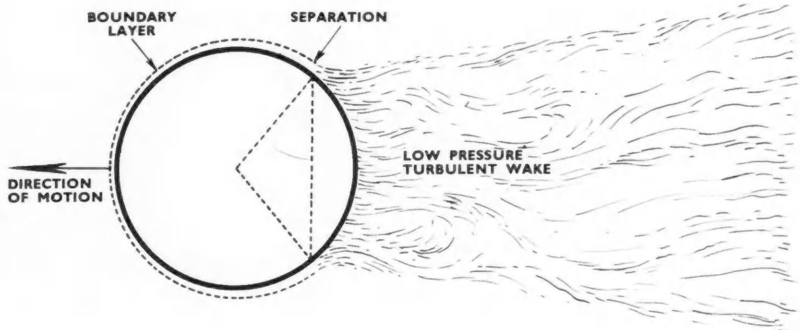


FIG. 5. Ball moving above the critical speed. The flow is now necessarily symmetrical. The boundary layer clings much further round the ball. The wake is narrower, but the pressure in it immediately behind the ball is higher than in 1, with the result that the retarding force (coefficient) is much less. The boundary layer can also be extended in this way *at lower speeds* by slight surface roughness introduced on the front half of the ball, and the resistance force is then similarly reduced.

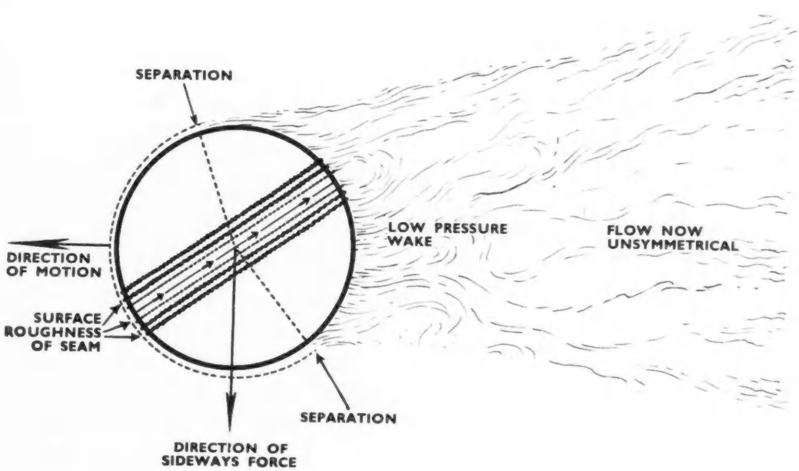


FIG. 6. Ball moving below the critical speed, but flow rendered unsymmetrical by the presence of the seam. (The ball is being viewed from directly above.) The roughness of the seam at the front of the ball (on the left as shown here) makes the boundary layer cling much further round on this side. On the smooth side the layer breaks away early on. The flow is not symmetrical. This results in an asymmetrical pressure distribution over the surface, and the resulting sideways force component makes the ball swerve.

(The seam stays in position because of backward spin given to the ball as it is bowled: the direction of this is shown by small arrows along the central line of the seam.)

(These drawings are not to scale: the thickness of the boundary layer is exaggerated in order to show it.)

resistance sets in. The breadth of the wake is similarly narrowed, and again the force of air-resistance opposing the motion is lessened to about one-fourth over a very narrow range of speed. This is the reason why grooves and dimples are patterned on the surface of a golf-ball, though the value of them was discovered more or less accidentally long before any theory of boundary layer motions was understood. (The most effective depth of golf-ball dimples, by the way, is found empirically to be about 14/1000 inch.) With smooth surface, a golf-ball cannot be driven anything like as far, for the reason that the critical speed for the smooth ball is far higher and difficult to exceed, whereas the surface ridges lower the critical speed, and so allow greater advantage to be taken of the much reduced resistance above the critical speed. To give actual figures: a golfer who could drive an ordinary ball 200 yards could drive a smooth ball only about 130 yards. But the character of the flight in the two cases is vastly different, and a comparison on pure carry (excluding rolling) shows an even wider difference in the attainable ranges.

RESISTANCE ON A CRICKET BALL

The actual force of resistance on a cricket ball is surprisingly large. For a critical speed of, say, 100 feet per sec., then just *below* this the resistance is equal to about the weight of the ball, whereas just above it the force is only about a quarter the weight. This suggests that for a bowler operating at and near the critical speed of the ball considerable differences of trajectory may result from minor changes in the starting speed. In the absence of detailed calculations it can only be a conjecture, but it does suggest that there may be some real mechanical basis for the claims one often hears of the ball being flighted in the air, and being made to dip suddenly.

It is perhaps worth remarking that all the present effects, and that of swing itself as we shall see, depend on the fact that the density of the air is just right for the critical speed to be attainable in the range of speeds that can be produced by unaided human effort. In a thinner atmosphere, such as on Mars for instance, a far higher bowling speed would be necessary to reach the appropriate Reynolds number.

THE EFFECT OF THE SEAM

To come now to the way the seam operates: the seam consists of a prominent band of six lines of stitches running parallel to each other right round the ball and holding the two halves together. The whole zone is about 3/4 inch wide, and when the ball is new the four outer lines of stitches stand out about 1/50 inch, that is, an amount approaching the depth of the boundary layer itself. Also, when the ball is new, the rest of the surface, nearly 90% by area, is smooth and shiny. As the ball is used, the seam stitches get flattened down somewhat, and the rest of the surface loses its shininess, and in some circumstances becomes roughened up quite coarsely.

If we imagine the air streaming horizontally past the ball with the general plane of the seam upright and in the direction of motion, then everything will be symmetrical on the two sides, and there can be no sideways force. But because of the effects of roughness described above, a change takes place if the plane of the seam is turned slightly to one side round the vertical axis. Suppose, for example, that the forward part of the seam is turned towards the bowler's left, so that the plane of the seam runs from mid-on towards the slips, through an angle of say 30° to the line of motion. It is now that the crucial effect of the seam can enter. The roughness of surface provided by the stitches at the front but to the left will operate to maintain the boundary layer more than half-way round the ball on this left side, even though the speed of the ball is less than the critical value. But on the right, the stitches will be too far round at the back to be able to have any influence since the boundary layer will already have broken away less than half-way round. (Fig. 6.)

The flow on the two sides is thereby rendered unsymmetrical, and we now arrive at a situation in which a sideways force can occur. It turns out that on the left, where there is a greater range of boundary layer, the total force of air pressure is less than on the right, and the ball experiences a force to the left that will deviate it sideways and make it move towards the slips. This force can rise to something like the weight of the ball itself on occasion when everything is just right. If the seam is turned the other way, with its plane running from mid-off to fine-leg, the situation is reversed and the deviating force is then to the leg-side.

WHY A ROUGH BALL WILL NOT SWING

It is clear that this sideways force can come into play only at speeds below the critical for only then can the extension of boundary layer be induced. We see that for the same reason a rough ball will not swing, because its roughness will keep the boundary layer everywhere fully extended, and the seam can have no further effect. It may also be predicted that a ball sufficiently roughened on one side but smooth on the other could be made to swing even though it had no seam stitches at all.

WHAT KEEPS THE PLANE OF THE SEAM SUITABLY POSITIONED

It should perhaps be explained how it is that the seam can stay in the required position as the ball moves through the air and does not stray away to spoil the effect. The answer lies in the small amount of rotation that is automatically given to the ball, almost in the backward direction, as it leaves the bowler's hand. Correctly bowled, the seam merely turns in its own general plane, just as the rim of a wheel turns. This, of course, may not always happen; the area of effective roughness produced by the seam when not so rotating may be much larger than the area of the seam itself, and the ball will not swing. So clearly part of the skill of swing bowling lies in getting the seam suitably orientated.

LATE SWING

One of the mysteries associated with swing bowling is the so-called "late swerve", in which the sideways deviation shows little or no sign of occurring until late in the ball's flight, and here again the explanation seems likely to be associated with the existence of a critical speed.

Clearly if the ball is started off above the critical speed, it cannot swing initially. But if this speed is not too great, the resistance of the air may be sufficiently large to reduce the speed below the critical value before it reaches the batsman. If the seam is properly set at this stage, swing may then occur in the later part of the flight only, in the manner explained.

To give a rough numerical illustration: suppose we have a ball for which the critical speed is 100 feet per sec., and that it is bowled at an initial horizontal speed of 105 feet per sec. The average force of resistance as it slows down through the critical range is more than half the weight of the ball, and so resistance could slow it to, say, 95 feet per sec. while the ball was travelling the first 45 feet towards the batsman. With the seam properly placed, the ball can already have begun to swing (since it is moving at less than the critical speed), and there is another sixth of a second before it reaches the batsman. Since the sideways force at maximum can be about the same as the weight of the ball, the subsequent sideways deviation could be about five inches. But this may be only a lower estimate of the late swing possible, since it is only the amount between the time it starts, or rather later, and the time it reaches the batsman. The ball will appear to deviate much more if it is allowed to pass the batsman and given time for the swing to show.

FACTORS AFFECTING SWING

The foregoing explanation of swing is based on the results of practical experiments with various-sized spheres in the airstream of wind-tunnels, though, one hastens to add, carried out without any question of the mysteries of cricket in mind by the experimenters. It appears that even under the more or less ideal conditions so provided, the critical speed is highly sensitive not only to surface roughness but also to seemingly minor irregularities in the airstream itself, such as the slightest degree of inherent turbulence. Different wind-tunnels, for instance, show the onset of the critical speed to occur at Reynolds numbers differing by a factor of two or more. There seems little doubt that it is effects like these that explain why a bowler may at one time be very successful in obtaining swing and yet at another fail altogether to produce it.

There are strong indications that humid sultry weather somehow affords the best conditions. One may conjecture that this may involve very small-scale irregularities of motion in the air, or, secondly, it may affect the roughness of the surface and so reduce the critical speed just enough to make swing more readily obtainable, or, thirdly, of course, it may do both. It has even been suggested that humidity simply swells the seam stitches to make them more effective in relation to the depth of the boundary layer. It is also well known that one new ball, apparently indistinguishable from another, may not noticeably swing at all, in so far as this can be established on the cricket field, and here again the slightest differences of surface roughness may be responsible.

To sum up: the principal factors that seem most likely to be involved in producing swing are, first, the condition of the air, and second, the size of stitches on the ball and the degree and location of minor surface roughness on the remainder of its surface. Nothing can be done about the first of these factors. However, if the controllable factors affecting swing were successfully isolated and reduced to measurement, then it might become possible to have a much more complete specification for a cricket ball (at present described only by size and weight), instead of leaving it largely to chance whether a ball will be suitable for swing bowling or not.

TWENTY-FIVE YEARS AGO

THE DISCOVERY OF THE NEUTRON AND RACE PREJUDICE

Our "Notes of the Month" for May 1932 continued on the subject of the neutron: "Many discoveries are made by accident, and in a limited sense this is true of the neutron. But whereas its existence was suspected some twelve years ago, this particle had to make itself known through the very sensitive instruments used at the Cavendish Laboratory, Cambridge."

Dr A. S. Russell contributes an article to the May 1932 issue, in which he says: "It is often said that the greatness of the discoveries made by the present generation is due not to its being so much cleverer than former generations, but to the excellence of the instruments and general technique which are employed. Technique certainly contributed a great deal here. In the Cavendish Laboratory is a set of instruments over which Dr Chadwick and his colleagues preside, of which they are very proud, which register accurately, automatically, and to a very great degree of sensitivity, particles and radiations of many kinds. (For example, a cosmic ray when it emerges from the blue automatically turns on the apparatus which registers it.)"

Dr Russell continues: "The discovery of the neutron has opened a region of research which is of great interest and promise. (It would appear now that the nucleus of beryllium consists of two charged atoms of helium and one neutron.) The atomic physicist will determine what other elements produce neutrons in this way. . . . Does the neutron, when it hits a nucleus, go slap through it, as a ghost is said to go through a wall, or does it rebound or stay incorporated in its target? These are some of the immediate problems for experimental investigation."

Also in "Notes of the Month" for May 1932, is an account of Sir Arthur Keith's address on race prejudice before the Universities Congress at Oxford. It is described as: "a bold attack on current problems of international politics from the anthropologist's point of view. He holds that the feeling for race and nationality is an all-powerful factor in the upward struggle of mankind. The evolutionary process, as he sees it, is one which leads to more, and possibly better, races rather than an organism for the production of wealth. It is this disparity between the result of evolution and man's economic needs which is the cause of the disharmony in the world today. The problem is how and in what conditions can this racial and national spirit be rationalised, so as to work harmoniously towards international peace. Science has no national boundaries, and as a man of science Sir Arthur Keith may be unduly optimistic in his reliance on the powers of reason. Recent events suggest that it may be long before the peoples of the world will, as he suggests, be prepared to submit their national impulses to examination, education, and, if need be, self-sacrifice before allowing them to emerge into action."

There was also an article on "An Interesting Study in Human Physiology" then being made by Dr Benedict at the Carnegie Institution of Washington.

ANALOGUE COMPUTING APPLIED TO GUIDED WEAPONS

Lt-Com. F. R. J. SPEARMAN, R.N.(Ret.), A.M.I.Mech.E., A.M.I.E.E., A.F.R.Ae.S.

Ministry of Supply

An analogue computer may be defined as a computing device in which numbers or values are represented by physical quantities such as length, angle, or electrical voltage. There is thus no great novelty in analogue computing, for the common slide-rule is a simple example of a manually operated analogue computer. Between the numbers and the physical quantities there must always be a scale, which may or may not be linear; in the case of the slide-rule this scale is logarithmic, with numbers represented by logarithmic lengths, and such lengths may be added manually to give a product to the same scale.

The advent of electronic analogue and digital computers has, however, now focused attention on the word computer and the main features of the two types will be briefly discussed. The electronic digital computer is essentially an arithmetic machine which counts electrical pulses just as a human being counts sheep, but it generally uses a scale of two instead of a scale of ten so that numbers can be represented by bistable elements. It is a development from the older mechanical desk calculating machine in which mechanical pulses are counted to a scale of ten by devices such as ratchets. The use of electronics has increased enormously the speed at which pulses can be counted and has enabled instructions or programmes to be prepared in advance so that complicated problems can be solved without human intervention. Nevertheless the digital computer remains essentially an arithmetic device which is only capable of giving answers when fed with an input of numbers and instructions as prepared by a human programmer, even though these instructions may involve the machine in making apparent decisions. If the input conditions change with time, or with some other variable, a new solution must be found for the new conditions and a digital machine thus computes a series of points on a graph. By virtue of its enormously high speed of computation the points can be very close together, but the digital computer nevertheless always gives a series of discrete answers.

By contrast the electro-mechanical analogue computer is not an arithmetic machine and does not count any more than a slide-rule counts. It is essentially a combination of electrical and mechanical components which form a computing system. The numbers, which are represented by physical quantities such as voltages and shaft rotations, are capable of continuous variation with time and do not move in discrete steps. On the mechanical side many age-old engineering devices, such as cams, can be termed computing devices if they form part of a computing system. However, as with the slide-rule in which greater accuracy is obtained by a greater scale length, so in an analogue computer greater accuracy can only be obtained by increasing the scale factor, to which, however, there is a practical limitation. The inherent accuracy of an analogue computer is thus less than that of a digital computer in which, provided the input information is accurately known, the computational accuracy is only limited, as in calculations made by human beings, by the number of digits computed.

When solving mathematical equations there is no time scale in computing. However, when an input quantity is varying with time, as occurs in computations on physical systems or when a computer is used as part of a system of automatic control, there arises the concept of computing in real time, that is, of computing at the same rate as that at which the actual physical change is occurring. The general-purpose electronic digital computer, despite its very high computing speed, finds it extremely difficult to compute in real time unless an inaccurate solution or widely spaced points are acceptable. It is in connexion with real time computation, or of computation as part of a control system, that the analogue computer excels.

From this discussion it is easy to see how the idea of simulators arises. For a complicated problem in control engineering, which usually includes several feedback loops, the full mathematical analysis is very difficult and tedious. To carry out experimental tests on a real system may, as in the case of guided weapons, present very formidable difficulties both from a practical and an economic aspect. The physicist or engineer therefore considers it advantageous to build a mathematical model of such a control system on which to carry out experiments; this mathematical model, which is termed a simulator when put into the practical form of a computer, must be capable of computing solutions in real time if any actual component parts of the physical system, of which it is a model, are to be included in the computation.

Analogue computing techniques thus generally form the basis of simulators and a mathematical model is built of analogue computing elements so that the separate component parts of the actual system, such as the airframe aerodynamics of a guided missile, form a self-contained computing block. To formulate the problem in mathematical terms the transfer function technique, as developed in the study of servomechanisms, is largely used. A typical simulator thus consists of a number of computing blocks, each set up to represent the transfer function of part of the system, and interconnected so as to represent the complete system. To the engineer, though perhaps not to the pure mathematician, the existence of a model, on which he can observe results and make alterations as he thinks necessary, is a great aid in the development of a real physical system.

COMPUTING TECHNIQUES FOR SIMULATORS

We have seen that a simulator is basically an analogue computing machine which is specifically designed to solve integro-differential equations with time as the independent variable. Analogue computing techniques may be electronic or electro-mechanical, but fundamentally they have to perform the mathematical functions of addition and subtraction, multiplication and division, integration and differentiation, and resolution; in addition various methods of dealing with non-linear functions are required.

It is necessary now to study the techniques by which solutions of equations may be computed. To take a simple example, consider the weathercock vane shown in Fig. 1. Owing to the restoring moment and air damping the vane will, when disturbed out of the airstream, execute a damped oscillation as it realigns itself with the air flow. The appropriate equation of motion is of the form:

$$\frac{d^2\theta}{dt^2} + a\frac{d\theta}{dt} + b = 0.$$

For simulation of this equation high gain directly coupled amplifiers, with suitable feedback loops around them, can be used to build an electronic system, as shown in Fig. 2, which satisfies the equation:

$$\frac{d^2V}{dt^2} + a\frac{dV}{dt} + bV = 0.$$

As this is the same equation as that of the vane, a record of the voltage (V) and its derivatives will show how the vane angle (θ) and its derivatives will behave as the damping (a) and the stiffness (b) of the system vary. It could be said with justice that it would be as easy, and probably cheaper, to test the vane itself as to test its electronic model, but such arguments do not apply when determining the more complicated, but very similar, "weathercock" oscillations which occur during the flight of a guided missile or aircraft. Here the cost and uncertainty of full-scale trials are so high that the construction of elaborate and costly simulators is fully justified.

For other equations which involve multiplication or resolution it is often convenient to use a servomotor in which, with one quantity represented by the shaft rotation and the other by the input voltage, the output voltage represents a product; however, the use of mechanical components slows down the speed at which computations can be made.

The accuracy of an analogue computer is often unfavourably compared with that of a digital computer. Its accuracy is generally limited by two factors, the static accuracy of such components as high stability resistors and condensers, and the dynamic performance of such components as electromechanical servomotors. Analogue and digital computing techniques should, however, be regarded as complementary and future simulators may have to make some use of digital techniques when they are required to give the greater accuracy required for particular computations.

The development of simulator techniques has largely

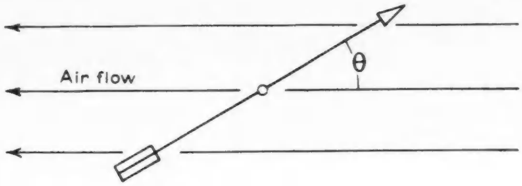


FIG. 1. Weathercock vane.

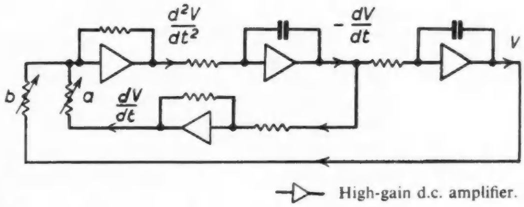


FIG. 2. Simulator for weathercock vane.

been carried out by those associated with aeronautics. The machines in use vary from the mighty Tridac, with its eight thousand electronic valves and nine electro-hydraulic servos, shown in Fig. 3 as installed at the Ministry of Supply's Royal Aircraft Establishment, Farnborough, to the small general-purpose analogue computer, such as shown in Fig. 4, of which several models are commercially available. The latter consist basically of a cabinet of some twenty directly coupled amplifiers, which can be easily interconnected with different feedback circuits so as to solve simple differential equations; other cabinets, which may contain non-linear computing elements, may be interconnected with the first cabinet when more complicated equations are to be solved.

Now that small machines are coming on the market there is little doubt that workers outside the aeronautical field will take advantage of the facilities available. For certain purposes, where real components or human reactions do not form part of the problem, it may be advantageous to have a simulator operate faster or slower than the real system it represents. Thus an economic process lasting for several days may be reproduced in a matter of seconds for quick analysis or a fast transient may be staticised for examination by a repetitive type of simulator; alternatively a very fast transient response may be slowed down to facilitate recording and study.

THE USE OF SIMULATORS IN THE STUDY OF GUIDED WEAPON PROBLEMS

Guided weapon systems are fundamentally servo-mechanism problems in three dimensional space. The input can be represented by the position of the target and the output by the motion of the missile, the object of the guidance and control system being to reduce the error between input and feedback, and hence of input and output, to zero within the time of flight of the missile. The complete servo system has several loops,

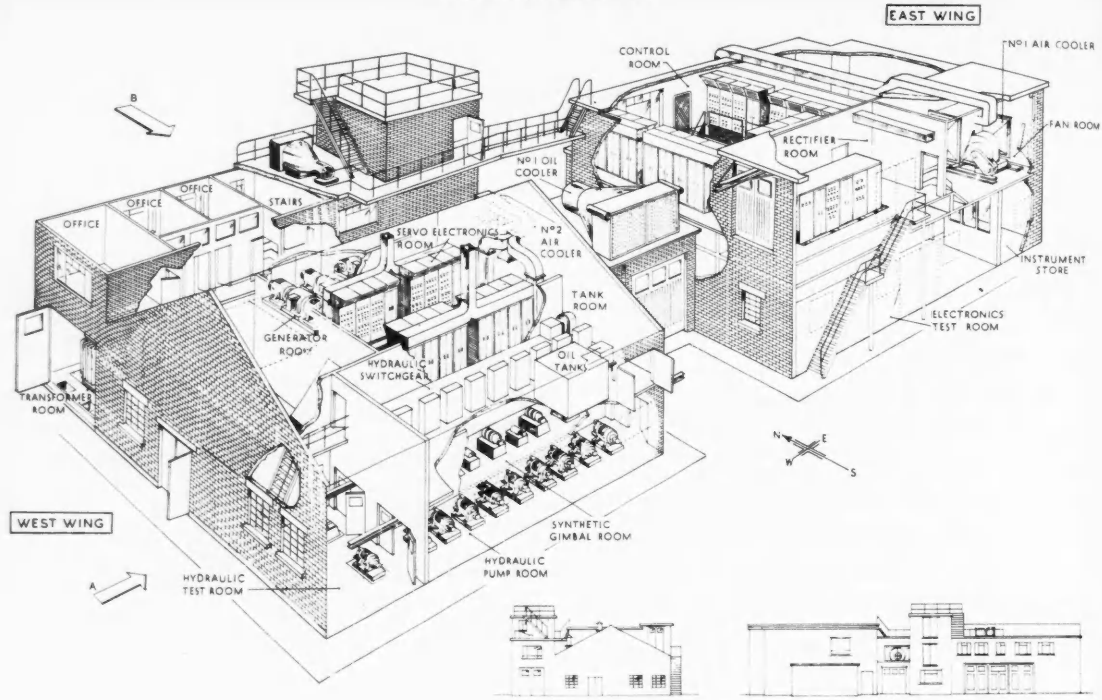


FIG. 3. Layout of Tridac.

such as the autopilot, guidance, and kinematic loops. The analysis of the complete three dimensional problem involves the use of a machine of the size of Tridac, but very useful work can be carried out by studying the problem in one dimension only on smaller simulators.

The complete guided weapon system includes the missile aerodynamics and autopilot and the guidance and navigation systems, all of which affect the missile trajectory. Simulator studies are particularly suited to evolving satisfactory guidance and navigation systems. Two guidance systems commonly used for missiles are beam-riding, in which the missile is guided along a beam connecting an external tracker to the target, and homing, in which the missile is guided along the sight line connecting the missile to the target. An advantage of homing guidance is that the inherent accuracy does not decrease with increasing range of the missile from the tracker as it approaches the target, and it is thus very suitable for the terminal phase of attack. The problem of developing a homing and navigation system which will both be stable and produce a small miss distance from the target is, however, a difficult one which is made even more difficult by the single shot nature of the firing trials and the attendant difficulties of obtaining experimental data. In order to explain the use which can be made of mathematical models and simulators in the development of guided missile systems a proportional navigation homing system will be analysed.

MATHEMATICAL MODEL OF PROPORTIONAL NAVIGATION HOMING SYSTEM

A homing system operating on a system of proportional navigation is one in which the rate of turn of flight line of the missile is made proportional, through the missile autopilot and aerodynamics, to the rate of turn of sight line of the target as seen by the missile. The law can be expressed mathematically as $p\theta_F = kp\theta_S$ where θ_F and θ_S are vector quantities and k is the constant of proportional navigation, or homing factor, which is generally required to be greater than two. A homing system thus consists of two parts. The first measures the rate of turn of sight line and provides the guidance signal to the second part, which controls and stabilises the missile motion. Since measurement of both rates is required relative to space axes it is necessary to provide a space datum in the missile and a convenient method of achieving this is to use a gyroscope. A typical homing system could thus consist of a radar device, such as a conically scanning radar, which would measure the rate of turn of sight line relative to a gyro stabilised radar dish, combined with an autopilot which measures and controls the missile motion in space by suitable instruments such as gyros and accelerometers.

For a cruciform missile with cartesian controls both rates require to be measured in or resolved into the two mutually perpendicular steering planes of the missile. For developing a mathematical model for such a missile

it is convenient to consider the problem initially in one steering plane only, the actual range of roll being immaterial since all the component parts in the missile rotate together in roll and a change of roll angle only results in apparent target motion. A diagram of the various axes in the missile pitch plane is shown in Fig. 5 for the typical homing system described above with the various angles, all of which are measured relative to the space datum, denoted by θ with the appropriate suffix. These symbols are used on the block diagram or mathematical model of the homing system, shown in Fig. 6, which is drawn in a form which is suitable for setting up on a simulator if the transfer functions of the blocks are known.

Referring to Figs. 5 and 6, the radar measures the difference between the axis of radar dish, θ_D, and the apparent line of sight, θ_{SA}, which is true line of sight, θ_S, as modified by random aberration. This difference, $\theta_{SA}-\theta_D$, is then smoothed in the radar filter to remove unwanted noise and fed, after amplification, to the precession device of the dish stabilising gyro, which may be coupled, either directly or through a servomechanism, to the dish. Provided the output torque from the torque motor is directly proportional to the current fed to it the rate of turn of the gyro in space, $p\theta_G$, which is the command signal passed to the autopilot, will be directly proportional to the apparent radar error, $\theta_{SA}-\theta_D$. Any error between the gyro and dish, such as occurs when a dish servomechanism is fitted to decrease gyro size, can be measured by a position pick-off, since the gyro acts as integrator. The dish is thus servo-driven to follow the motion of the gyro.

The autopilot command signal, modified as necessary by a network and multiplied by the homing factor, k, is fed to the servomechanisms which drive the wings of a moving-wing missile or the control surfaces of a fixed-wing missile. The incidence given to the wings, either directly or through body rotation, provides the aerodynamic lift necessary to give the missile a linear acceleration and a rate of turn which is proportional to the rate of turn of sight line.

Finally the motion of the missile in space changes the line of sight through the kinematic loop, which represents the relative motions between missile and target. The missile is thus constrained to follow a trajectory, which will vary with the value of the homing factor and other parameters, but which will tend to bring the missile and target into collision.

From the block diagram of Fig. 6 it will be seen that it is fairly easy to set up on an analogue computer the representation of a typical homing system in one plane. By having two such set-ups with various cross-coupling links the problem can be solved simultaneously in the pitch and yaw planes and the effects of interactions between planes studied. By the use of a machine such as the Tridac the problem can be studied three dimensionally and the effects of various aerodynamic, guidance, and autopilot cross-couplings, other than inertia couplings, can be assessed. Other effects, such as the dish motion being not entirely independent of the missile motion, will be caused by imperfections in the servomechanisms and instruments, and further time lags may have to be introduced to smooth out noise. By carrying out a series of simulator trials the system may be optimised for a particular application.

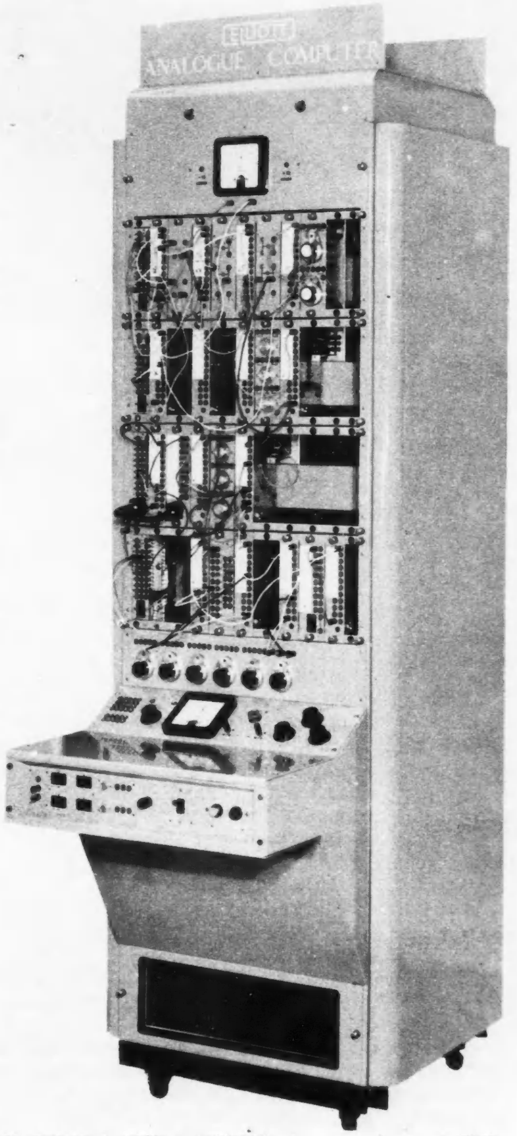


FIG. 4. General purpose analogue computer.

SYSTEM TRANSFER FUNCTIONS

As stated previously the mathematical transfer functions of the blocks must be ascertained in order to simulate any system. This involves studying the performance of the instruments, of the amplifier, of the

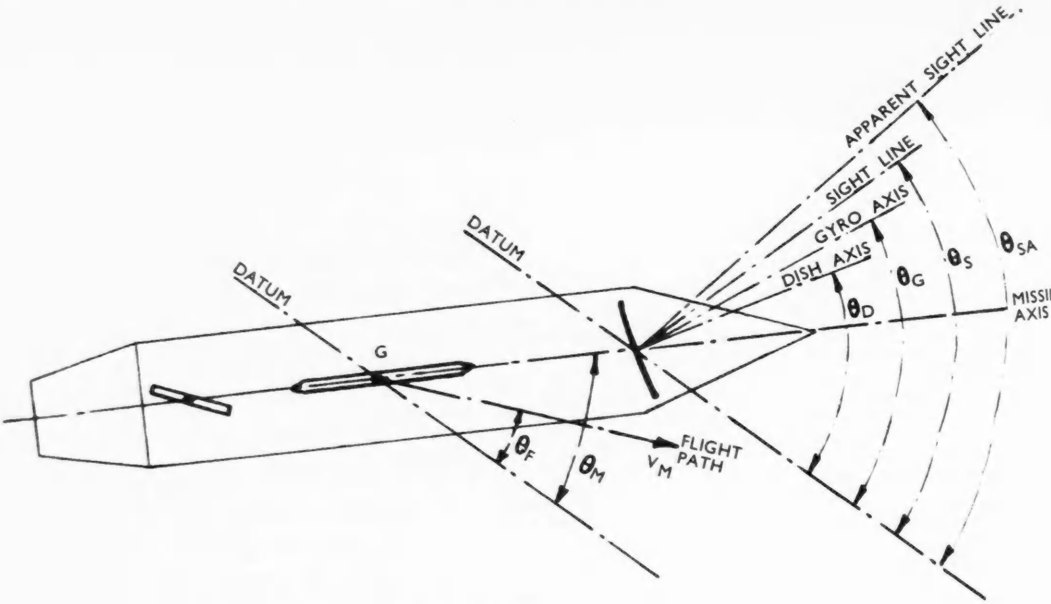


FIG. 5. Axes for homing system.

servosystems, and also the aerodynamic performance of the missile, under true environmental conditions.

Space does not permit a discussion of the form of all the transfer functions in the system, but some comments will be made. In order to minimise the amount of computing equipment required it is clearly desirable to keep each transfer function as simple as possible consistent with accuracy of simulation but the magnitudes of the errors resulting from such approximation require to be assessed. When a unity time-scale computation is made the effects of approximations can sometimes be checked by substituting the real component, which may have a non-linear characteristic.

Servomechanisms can usually be represented approximately by a first-order system representing a simple time lag or a second-order system to include inertia effects. An instrument, such as the precessing gyro, can be represented by a perfect integrator or an integrator with a time lag. Other instruments can be represented as is appropriate to their function, and passive networks can be accurately represented.

The question of aerodynamic transfer functions has been studied and for fixed-wing missiles relatively simple transfer functions, based on linear theory and certain approximations, have been derived. The aerodynamic transfer functions are derived from the stability derivatives commonly used in the aerodynamic field and give the relationship between the control surface deflection and the resulting airframe motion.

For a fixed-wing missile the transfer function can be expressed in terms of four main parameters, the steady state rate of turn per unit control surface deflection (K_q), the natural frequency (ω_n) and the damping ratio (γ) of the weathercock motion of the airframe, and the incidence time lag (τ_a).

The expressions for the pitch plane transfer functions in terms of the operator, p, and of these parameters are:

$$\frac{\theta_F}{\eta} = \frac{K_q \omega_n^2}{p\,(p^2 + 2\gamma\omega_n p + \omega_n^2)},$$

$$\frac{\theta_M}{\eta} = \frac{K_q \omega_n^2\,(1 + \tau_a p)}{p\,(p^2 + 2\gamma\omega_n p + \omega_n^2)},$$

$$\frac{\alpha}{\eta} = \frac{K_q \tau_a \omega_n^2}{p^2 + 2\gamma\omega_n p + \omega_n^2}.$$

The values of the aerodynamic transfer functions, which are seen to be standard first- and second-order equations, will vary with height as the air pressure and density vary. It will be seen that the incidence time lag, which is the steady state ratio of incidence to rate of turn, is the time constant of the rate of decay of flight line into coincidence with missile axis in response to a step function. It is one of the most important aerodynamic parameters in the design of homing systems and will clearly be greater at high altitudes.

The kinematic equations, since they represent the geometry of the relative motion between target and missile, require to be accurately computed without appreciable time lags, but they do not contain any parameters, except the missile performance, which can be changed in order to optimise the system for a particular tactical operation.

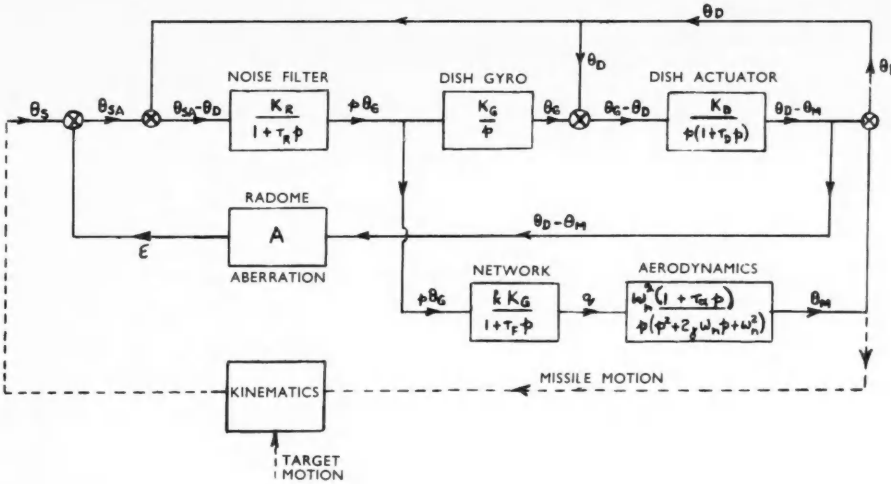


FIG. 6. Block diagram for homing system.

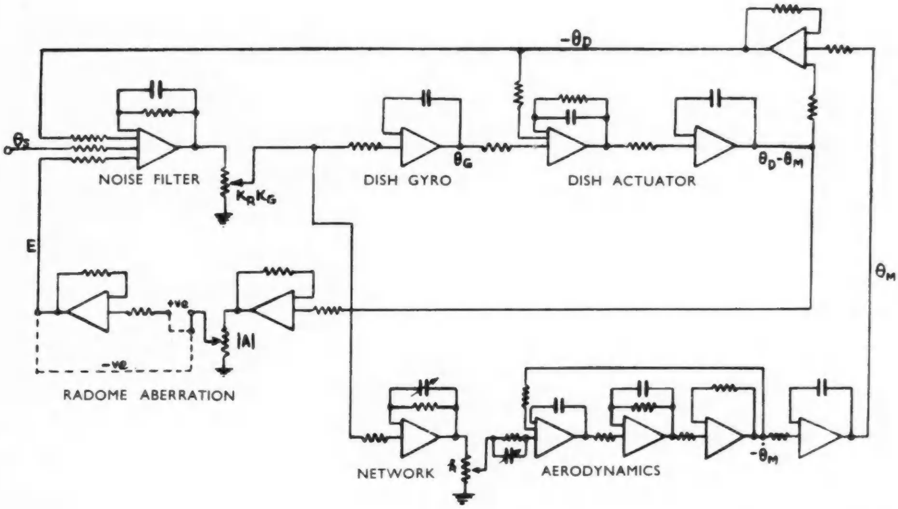


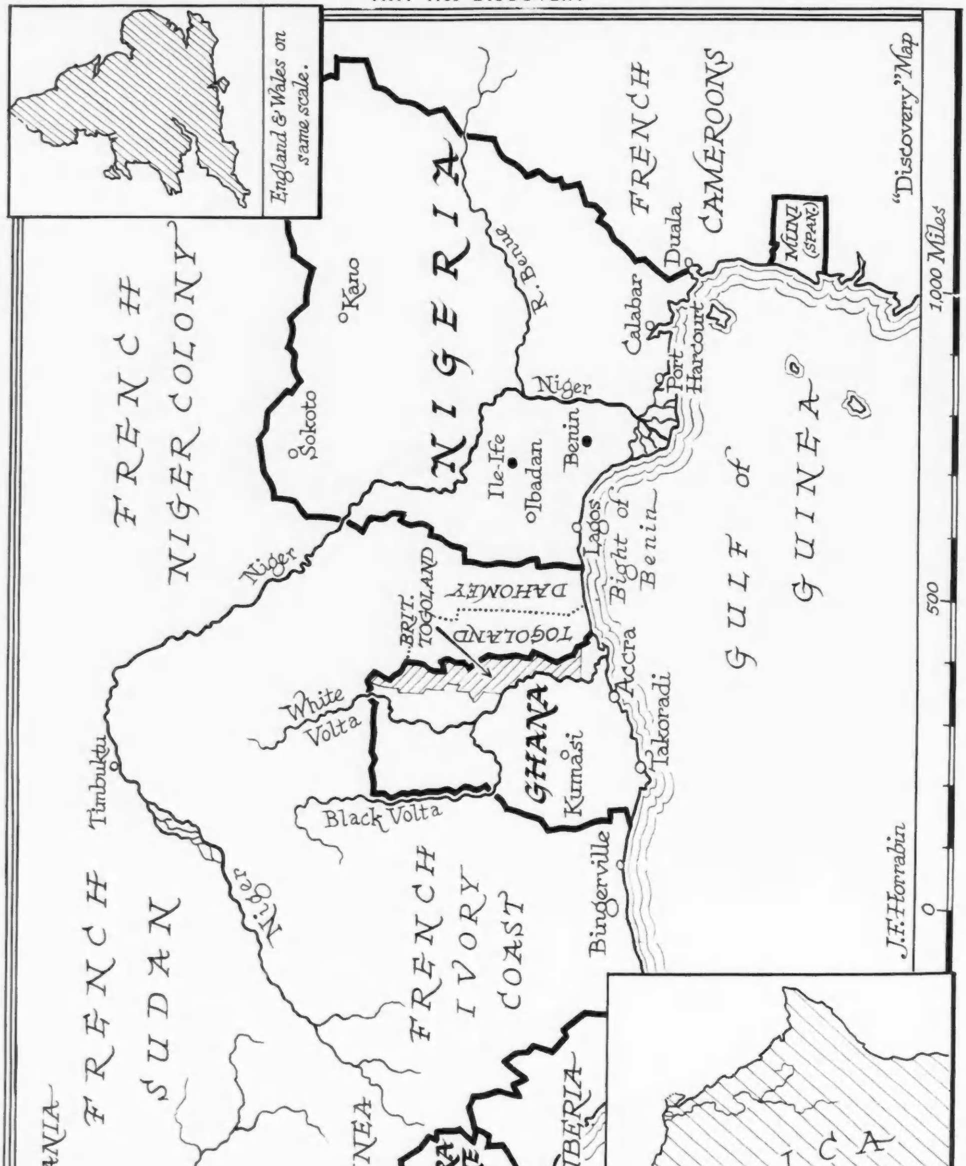
FIG. 7. Circuit diagram of simulator set-up for guidance and control loops.

CONCLUSION

The final step, after having devised a mathematical model with known transfer functions, is to set up a simulator to represent the system. By using standard analogue computing techniques the circuit of Fig. 7, which represents the guidance and control loops, can be drawn. A simulator, on which experiments can be carried out to optimise the system, can then be constructed from standard analogue computing units.

The computing accuracy of results obtained on analogue computers can be checked, in comparatively slow time, by digital computers, but the soundness of the assumptions and approximations made in simulating the problem can only finally be checked by actual flight trials, where inertia effects are included. The cost of such flight trials is, however, so much higher than the cost of performing similar experiments on simulators that there is an obvious advantage in keeping to a minimum the number of system development flight trials. To develop reliable components for the real system many flight trials are still necessary, though the development and use of test gear for simulating the environmental conditions of, for example, temperature, acceleration, and vibration, under which the components are required to work reliably, should help to decrease component testing flight trials.

The complexity of simulation required is a measure of the complexity of the problem to be solved. Enough has been said to show the usefulness of simulators in the guided weapon field. Their use is now spreading to the many other fields in which they can assist development.



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Oba Akenzua II of Benin in procession during the actual sacrifices to his head. He wears a crown and upper garment of coral beads and an embroidered cloth of local manufacture. The red "wands" carried in front of him replace the shields which are shown on bronzes depicting kings of the past on similar occasions.

BENIN, A WEST AFRICAN KINGDOM

PHILIP DARK, M.A., Ph.D.

Leverhulme Research Fellow, University College, London

When one sees a painting for the first time the first reaction to it may be one of pleasure at its colour or its subject; the form of a new sculpture may be particularly pleasing to the eye. This first reaction, our perceptual experience, is, in most of us, quickly followed by ideas we have as to how things that are familiar to us should look. If the painting is one of figures in a landscape that is like something we know from past experience, we may find that the picture pleases us because the artist has expressed something we know about. We have concepts as to how things should look, we have values we place on things that are familiar and which we think are good or bad. Something new that is unfamiliar, that we find difficult to relate to our past experience of things, people and happenings, makes us unsure of ourselves. If it is a work of art which does not fit into our concepts of how things should, in general, look, we may say that we like its colour, but what does it mean? Its appearance may seem to us quite remote from our own traditions of art and we recognise this fact, but, feeling a need to relate it to our previous ideas about art, immediately ask where does it come from? Who made it? Why was it made as it is, for what purpose? When was it made? These are some of the questions for which the ethnographer has to find answers when analysing an alien art tradition. To discover why a particular art takes the form of expression it does, requires that we should learn about the customs and ways of living of the people who produce it. Learning about the culture of the people will give us an understanding of their art and enhance any pleasure we may derive from it, for appreciation of an art form is dependent on our perceptual and conceptual experience, our pleasure at it and knowledge of it. In this article I shall indicate some of the ways one sets about trying to find answers to the types of questions that have been posed by considering

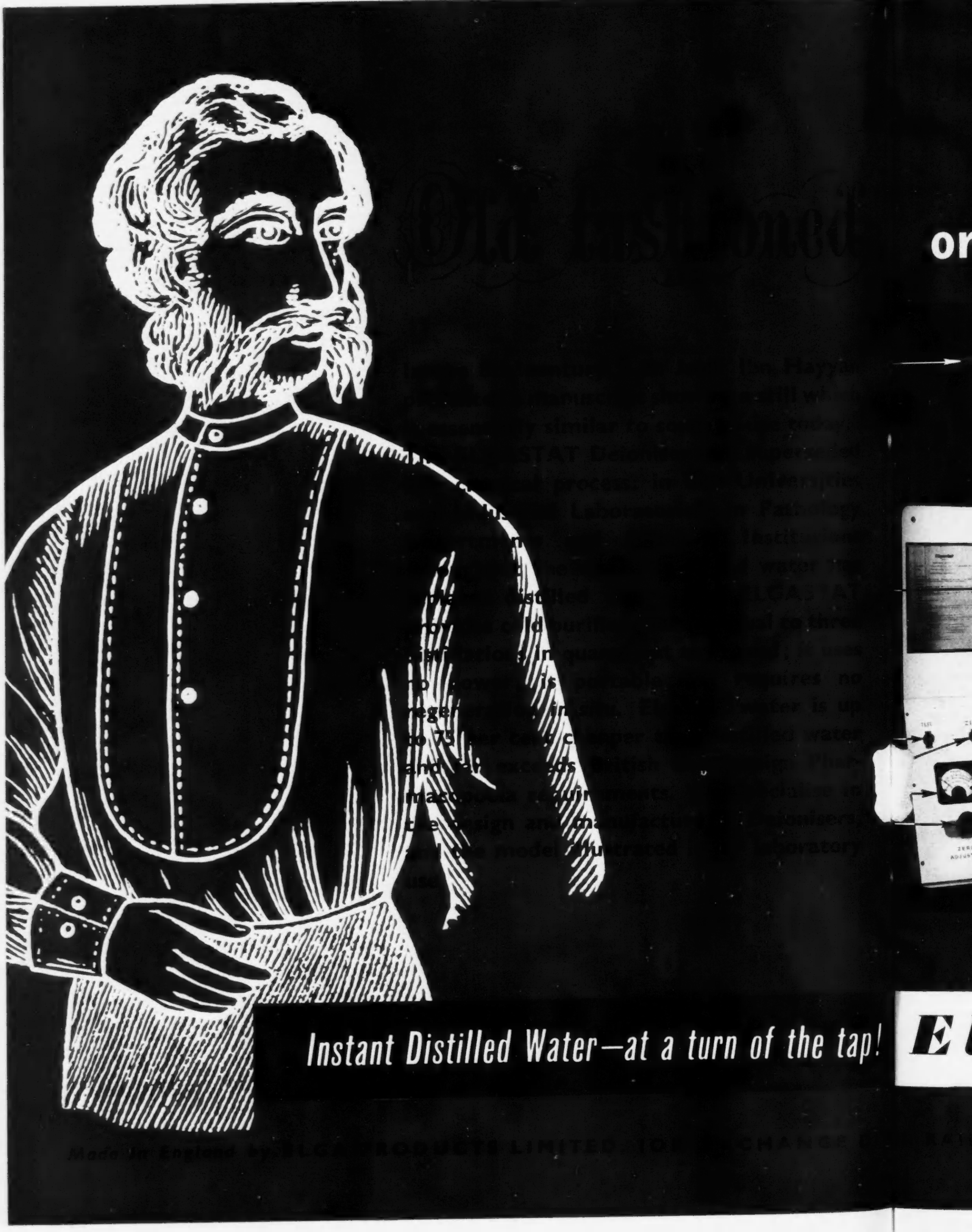
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FIG. 1 (*above*). Bronze Plaque. Oba with attendants.

FIG. 2 (*right*). Bronze Plaque. Figure of a bearded European with a hat with two feathers, wearing a sword and holding a trefoil-headed pike. He is attended by a small European. Two busts of Europeans decorate the top left- and bottom right-hand corners.

(*Opposite*). The Osuma of Benin, one of the Senior State Chiefs, in full ceremonial dress. Note the bronze bell and armlets and the mask at his waist.

All monochrome photographs in this article are published by kind permission of the Trustees of the British Museum.

an art that originates from West Africa and which has found world-wide acclaim as a great tradition; this is the art of Benin.

GEOGRAPHY AND HISTORY

Benin is an important town of the Western Region of the recently proclaimed Federation of Nigeria. It is situated in 6° 12′ north latitude and 5° 45′ east longitude (see map), and lies in the tropical forest region of West Africa. Benin has always been the capital of the Bini nation, which has lived in the area of the delta of the Niger River for many centuries. Traditional history recounts that the first king of the second dynasty of rulers was Eweka I, who reigned possibly as early as the 13th century, the fifteenth Oba having ruled in 1485, when the first Portuguese visitors arrived in Benin. The territory of the Benin kingdom varied over the centuries, but it was the dominant power in southern Nigeria, extending beyond Lagos to the west and to the Niger River to the east. Today, Benin city has a population of some 54,000; the present Oba (Oba means king), Akenzua II (see colour plate), the thirty-seventh Oba since Eweka I, is the king of some 300,000 people.

DISCOVERY OF BENIN ART

Benin art first came to the attention of the world at large as the result of a British Expedition sent in 1897 to punish Oba Ovonramwen for murdering Mr Phillips, the acting Consul-General, and his companions. Mr Phillips, with several other Europeans, had decided to visit Benin to discuss with the Oba the question of trade and the abolition of human sacrifice. The Oba had said that he was celebrating the anniversary of his father's death and could not see Mr Phillips for some months after the proposed time for the visit. In spite of this message and a warning from European residents not to go, the party set out and was massacred. The news of the massacre reached London eight days after the event

FIG. 3. Brass mask for the Ododua masquerade which occurs as part of a state ceremony; 4 cicatrices above each eye, as in Fig. 4. The pupils of the eye are of iron. Height 13 inches.

FIG. 4. Bronze head of a queen mother. Headdress of a network of beads; 4 cicatrices above each eye with two bands between. These latter and the pupils of the eye are inlaid with iron. Height 15½ inches.

and a punitive expedition was despatched within a few weeks. The expedition found a large number of bronzes in relief and in the round, carved tusks and wooden objects which it proceeded to sack. The murder of the English officials, the subsequent punitive expedition, and the discovery of this vast treasure of art objects caused public attention to focus on Benin, and its art drew wide interest. The objects brought back from Benin quickly found their way to museums or were bought by private collectors. The largest and most important collections were acquired by the British Museum, Lieutenant-General Pitt Rivers (now in the Pitt Rivers Museum, Farnham, Dorset), the Museum für Völkerkunde, Berlin, and by museums in Hamburg, Dresden, and Vienna.

TECHNIQUES

Benin art, which has been produced for several hundreds of years and which is still made, consists mainly of castings in bronze and brass and carvings in wood and ivory. Headdresses and costumes were made of beads and other materials; cloth was woven and pottery made, but few such articles, which are made of perishable materials, survive. Wood too, of course, does not last long in the tropics, so that the wood carvings that we see today were probably made fairly recently; but many of the castings in bronze are reputed to be old, perhaps some are as much as 600 years old. The Bini used a technique of casting known as the *cire-perdue* (lost-wax) process, and the bronzes they made are as fine as any work produced in the same way in Europe. They made bronze plaques picturing people in the costume of the times with various weapons of war and European voyagers (Fig. 2) who visited Benin in the early days of the exploration of Africa; they showed animals such as snakes and leopards, Obas in full regalia with their attendants (Fig. 1), scenes of sacrifice

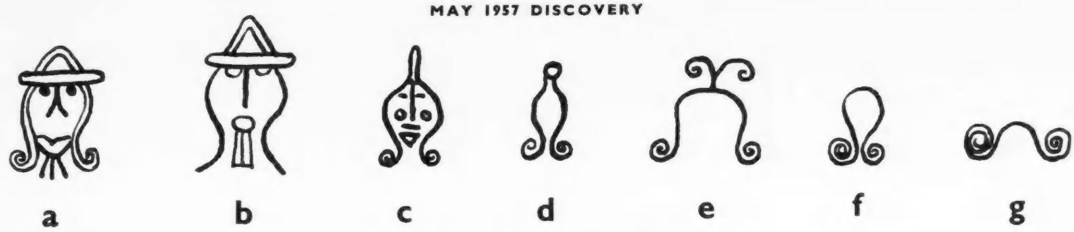


FIG. 5. Motif deriving from European head (?).

and many other aspects of the life of the people. Similar human and animal scenes were cast in bronze in the round. Weapons were made of bronze and iron, often decorated; elaborate staffs of office, with human and animal figures, were sometimes cast in metal and sometimes carved. Armlets and anklets of ivory were richly decorated by carving. Bells of bronze were cast and ivory tusks were elaborately carved with scenes of Obas and their court attendants, similar to the work in bronze. Portrait heads of people were carved in wood or cast in bronze (Figs. 3 and 4) and many other articles were made, but it is their highly skilled bronze-work which first draws attention to this remarkable art.

ART AND BENIN CULTURE

Art is not an isolated phenomenon; it is an aspect of the life of the people who produce it. It reflects their thoughts and often shows the way they live. In many parts of the world we find arts which are pictorial, or narrative, in the sense that they portray important kings and their consorts, political events and religious ceremonies, deeds of war, and activities of peace. Benin art appears to tell us much of the history of the Bini people. To understand the art we must not only examine the objects themselves but must search other types of sources which will provide us with evidence as to the meaning of the people and objects portrayed in bronze and other materials. As Benin art objects have been made for several centuries, but at what specific times we do not know, accounts of early travellers to West Africa will have to be examined and the evidence from archaeological excavations sought. Evidence from the contemporary culture may give us a clue as to the meaning of a past custom; the traditional history that the Bini have had handed down to them by their forefathers may help us to understand a scene portrayed in bronze by the Bini artist some three hundred years ago. The problem of understanding Benin art, therefore, is one of blending all these types of information into an historical whole. We have to marshal all our evidence from these different sources so that we can discover how Benin art originated and how it developed over the centuries to the present day. Unfortunately, many of the different sources we might draw on are lacking in the type of information we require. Some accounts of early travellers are useful in giving an idea of some aspects of the life of the people and not of others. Historical accounts for one period exist, but not for another. Research in libraries and archives might lead to the discovery of datable objects and permit us to date those now in various museums. Recent field work in Benin by Mr Bradbury, who took the coloured photographs illustrated on pp. 199 and 202 given us much valuable information on how the Bini people live today, which helps us to reconstruct how they lived in the past, but his work is not enough. Although we are, therefore, lacking evidence for a full understanding of Benin art and how it originated and developed, we have sufficient information available to consider the way in which it may have originated and how we would arrive at its meaning.

Shortly after the 1897 Expedition, scholars first thought that the Bini must have learned the art of casting in bronze from the Portuguese, who were the first European travellers to visit Benin. Later and more detailed investigations showed that the Bini knew how to make bronzes by the *cire-perdue* technique before the advent of the Portuguese. The Bini themselves claim that they learned the art from Ile-Ife, a city some 100 miles to the north-west, which was the capital of the Yoruba peoples, neighbours of the Bini. In recent years, wonderfully cast bronze heads, as well as heads and figures in terra-cotta and stone carvings, have been excavated at Ile-Ife. How old they are is a matter for speculation, but present opinion is that they were made before West Africa was discovered by Europeans in the 15th century. The Bini tell how Oba Oguola, who—it is claimed—ruled about A.D. 1280, sent to Ile-Ife and how Igue-ighae, a famous artist, was sent to Benin by the King of Ile-Ife to teach the Bini how to cast in bronze. When Igue-ighae died he was deified and is worshipped today by the smiths at Idunmwu Igun Eromwo, the quarter of the royal brass founders. In the compound of the Ine, the head of the brass-founders' guild, is an ancestor shrine with a series of terra-cotta heads, which Igue-ighae is said to have brought with him from Ile-Ife as models for his teaching. The terra-cotta heads on the altar of the shrine are quite probably copies of copies of the originals, but help to testify to the truth of the story, for they are like the Ife pieces. Since the Punitive Expedition, a number of bronzes have been found in Benin during excavations undertaken to rebuild the palace of the present Oba. This palace is built on a site which, it is said, was used in the 12th and 13th centuries as a cemetery. Some of the bronzes found are very similar to the works found at Ile-Ife and indicate, at least, a close connexion between Ile-Ife and Benin. Many scholars accept that Benin art originated from Ile-Ife, but the art of Ile-Ife that we know from recent archaeological finds only tells us of an art fully

developed and of a kind as sophisticated as any to be found in Europe. Did this art form develop at Ile-Ife or, if not, from whence did it come and thus how did Benin art originate? Various theories of origins have been put forward. One that finds favour is that the art of casting by the *cire-perdue* technique came from Egypt some time between the fifth and seventh centuries A.D. The evidence to support this theory rests on the facts that the same technique of casting was in use in Egypt from 1600 B.C. onwards, and that the Yorubas of Ile-Ife have a tradition of coming from the East about A.D. 600, when a great migration, called the Kisra migration, is claimed to have taken place. The technique, it is supposed, was brought to West Africa from Egypt during that migration.

STYLE

In any serious analysis of an art attention must be given in detail to its formal qualities. One must 'take to pieces' all the different objects, seeing of what forms, shapes and patterns they are made up, how these are all fitted together; in other words, how it all works. This will help us towards understanding the meaning of the art. In this process of dissection it may be noticed that in a collection of similar objects, such as a group of heads, there are small differences between each in the way the eye is shown, the form of the ear, and how the hair is modelled. Differences which enable us to diagnose styles may suggest to us that in a series of similar objects certain ways of showing such features are indicative of an early style and a later one; the manner of showing the eye, the ear, and the hair has changed or developed as time has passed from one way, or convention, to another. German scholars, in examining the differences between a number of features of bronze heads and figures, have put forward such a sequence of development and, relating it with other information, have proposed that there were definite periods of artistic development for Benin art to which they assign dates. Heads similar to that shown in Fig. 4 are thought to be earlier than those similar to Fig. 3. The differences between the features of these two heads can be seen by comparing the eyes, nose, or lips. However, there are large numbers of other art objects, such as plaques (Figs. 1 and 2) with single human figures or with two or more humans, or carvings of humans and animals on ivory armlets, all of which require examination before a series of objects can be set up in a sequence of development and dated with any certainty.

MEANING

Another problem in the analysis of an art is that of its meaning. Based on the differences in appearances of the art forms, two principal kinds of meaning have to be sought. First, there is the problem of identification, of identifying all the forms, or objects, pictured, such as the type of costume worn, the types of necklaces and collars used as ornaments, and the weapons carried. As the Bini artist generally copies these as they are, or were, in actual life, the problem is to decide what they were called by the Bini, when they were worn or used, and for what purpose. An historical source may describe such objects; the people themselves today may know what they mean. For example, the coloured illustration on p. 199 shows the Oba Akenzua II arriving in procession at a recent state ceremony. On either side of him are two attendants who ordinarily support his arms. To the front are two other attendants carrying wands. The Oba's collar, headdress, shirt, and necklaces, all of beadwork, are made by the Iwebo, or chamberlains, one of three main palace associations. His skirt of cloth, covered with pictures of himself, is specially woven and embroidered by a special guild. The Oba's ivory armlets are the work of another special guild. If we compare this photograph of Oba Akenzua II with the plaque shown as Fig. 1, we see on the plaque a similar scene of an Oba with his attendants. He wears a bead cap, collar and necklaces, as Akenzua II; similarly, a skirt covered with pictures of himself. The two larger attendants are supporting shields, which, in the contemporary picture, have been replaced by wands. Crowns are different for different Obas, but some plaques show crowns similar in shape to that worn by Akenzua II. Similarly, though in Fig. 1 the diminutive attendant on the left is carrying a sword of a different shape from that borne by Akenzua II's attendant, there are other plaques which depict exactly the same shaped sword. Though many changes have occurred in the life and customs of the Bini in the modern era, it does appear that many aspects remain much the same.

Second, there is the problem of the meaning of various decorations and the way they are used on the objects. Fig. 5 shows a number of designs appearing on different objects. The grouping, *a–g*, suggests that there is a relationship between the various motifs shown, *f* and *g* having derived from the curls of the long hair on each side of the face of *a*, which is a European face. A detailed examination of all similar motifs present on Benin art objects might lead us to conclude that one particular type was the forerunner of another and hence objects having the former could be placed earlier in time than those having the other motif. Or, *f* might be meant as nothing more than a shorthand version for the other, *a*, and simply mean a European head. The examination might, however, lead to the conclusion that the similarity was a matter of chance, for *f* is quite a common motif in West African art. It is, nevertheless, in this way, of making comparisons, setting up sequences of similar items, that meaning may come forth to be added to our other information.

CONTROL OF DATA

One of the big difficulties that has to be overcome in this type of work, as in many others, where several thousand objects required detailed examination, let alone historical sources in several languages and large bodies of information on present-day life and customs, is the control of all the data. Advances in the field of information searching and also in documentary reproductive techniques have been considerable. We now have available ways of controlling large bodies of information so that in a very short time we can extract from it

the answers we need. Microfilming enables us to have a complete visual record of all Benin art objects and rare historical documents in our own hands rather than scattered in museums and libraries. But supposing we had such a record, we still want to find a particular item in it as quickly as possible. This we can do by classifying the material we have and keying our classification to some quick-finding tool, such as a card-index. But such a tool is really only satisfactory for relatively large groupings of data and not for all the details of the forms and designs of Benin art which have to be analysed. All the details can, however, be controlled by using punched cards in the same way as the chemist employs them to search for chemicals having the same properties. Each object of Benin art has a number of identifiable forms combined in a certain way and our objective is to find and compare similar objects and similar forms in order, together with historical and contemporary information about them, to discover their properties.

The road to understanding an art form can be a long one. In the case of Benin art it might be asked whether it is worth all the labour. It is certainly important to the historian, for an understanding of Benin art means an understanding of Benin history. A history of Benin means that for the first time we would have a large block of history of an area of Africa where the past is poorly known. Above all, it is worth while for the people themselves.

ANNÉE GÉOPHYSIQUE INTERNATIONALE
1957 1958
INTERNATIONAL GEOPHYSICAL YEAR

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Magga Dan *made a triumphant return to London River from the Antarctic on March 13. The ten members of the Royal Society advance party were welcomed at the quayside by the President and Secretary of the Royal Society; Sir David Brunt expressed the Society's "pride and gratitude" in their achievement.*

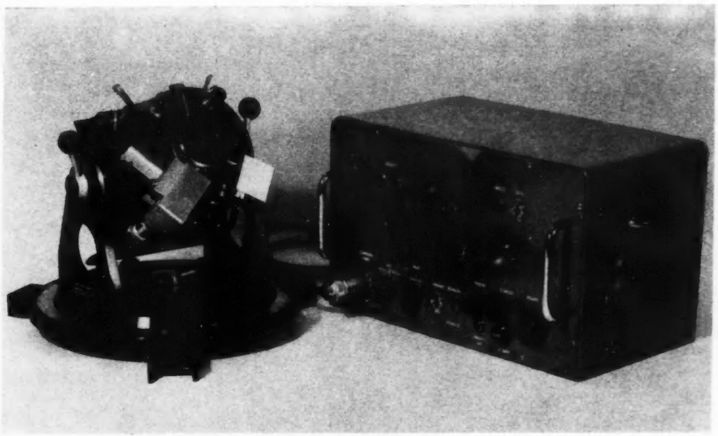
Also aboard were the two returning members of the Trans-Antarctic advance party, home safe now after their year's ordeal at Shackleton.

First Flight of the *Skylark*

On February 13, *Skylark*, the British upper-atmosphere research rocket, performed its first successful flight test from the special launcher installed at the Woomera rocket-range in Australia. The test was described by Mr Howard Beale, the Australian Minister of Supply, as "a complete success". It nevertheless bears little resemblance to the performance for which the rocket vehicle and the experiments associated with it for the IGY are designed. The reason is that *Skylark*, in accordance with the usual practice adopted for the first firings of uncontrolled rockets, was fired into a flat trajectory. The rocket travelled 20 miles, rising to 40,000 feet (nearly 10 miles). On this first flight-test *Skylark* performed no upper atmosphere experiments. Several more tests are to be conducted soon, and thereafter the first research flights will be made in Australia.

Two versions of *Skylark* were described in the paper on the project given by members of the Royal Aircraft Establishment at the American Rocket Society meeting in November 1956. Mark I would have a ceiling of about 93 miles (490,000 feet) and a payload of 65 lb. A later version of the rocket will have a boost-motor that will give a short-period acceleration and will carry the rocket above the 100-mile threshold.

Six research groups, co-ordinated under the Gassiot Committee of the Royal Society, have prepared experiments for *Skylark*. These are directed to: obtaining temperature, pressure, density, and wind profiles of the atmosphere from about 20 miles up (balloon ceiling) to the limit of *Skylark*'s capacity (about 130 miles high for Mark II); analysis of some of the electrical and



First production model of ballistic camera for use with grenade experiment from Skylark Rocket. Only the lens and shutter are standard. The actual camera is now at Woomera and will be used without further modification for the trials. Developed at University College, Physics Dept., under supervision of Dr P. J. Bowen.

chemical properties of the atmosphere above 45 miles high, and particularly of the E and F layers of the ionosphere. The second group of investigations is also expected to produce further data about temperature and winds.

The Royal Aircraft Establishment, the Meteorology Department of Imperial College, London (Prof. P. A. Sheppard); University College, London's Physics Department (Prof. H. S. W. Massey, F.R.S., and Dr R. L. F. Boyd); and the Department of Applied Mathematics at The Queen's University, Belfast (Prof. D. R. Bates, F.R.S., and Dr E. B. Armstrong), each have an experiment devised to yield data on the movement, pressure, density, or temperature of the upper air.

The University College group, and Prof. Bates of Belfast's team, also have experiments in the second group, that relating to the electrical and chemical properties in the ionospheric region. Dr W. J. G. Beynon, of the Physics Department of the University College of Swansea, in conjunction with Mr G. Ratcliff (of Bangor), the Royal Aircraft Establishment and the R.N. Scientific Service has further experiments of this kind. The Physics Department of Birmingham University (Prof. J. Sayers) is also to conduct independent ionisation experiments from the rocket.

Skylark: Upper Air Measurements

Only one of the experiments will attempt to measure such data directly; all the others will get at the facts by measuring something else. The **RAE team** proposes to incorporate gauges in the nose of the rocket itself, which will give ambient air pressure, temperature, and density readings. No details are available of the height range of this experiment, nor of the design of the equipment to be used; it is understood, however, that the latter will differ in some respects from the instruments in use for some time in rocket flights in the States.

The **University College group** are to measure temperature and horizontal and vertical wind-speed up to 60 miles or more by means of a sound-ranging technique. This is an ingenious method requiring several specially designed wide-angle cameras and an electronic computer. The experiment depends for its operation on the fact that the speed of sound in the air is proportional to the square root of the air temperature; the variation of temperature at a range of heights can be deduced from the variation of speed taken by the sound to travel through the intervening layers of atmosphere; it travels more quickly if the air is hot, more slowly if it is cold. The travelling-time of sound from a point in the upper atmosphere will be checked against the speed of light (virtually instantaneous) from the same point. This is managed by firing a series of grenades (visible and audible) that are to be ejected from the rising rocket every two seconds; not more than eighteen grenades would be used on a single rocket flight. Analysis of the data so obtained yields not only the required variation of the speed of sound as a function of height, but also the displacement of the downward-travelling sound-waves by winds at intermediate levels. The data obtained by the grenade method is said to be very accurate, but, since the rocket travels a great distance in two seconds, a pattern of spot readings rather than a continuous profile of wind direction is likely to result. It is thought the range of this experiment could be extended up to 130 miles. The special cameras and other equipment have already been sent to Woomera.

The especial virtue of the experiment devised by the **Imperial College group,** organised by Prof. Sheppard, is that it should yield just such a continuous profile of wind speed and direction. Its range lies between the met.-balloon ceiling (about 13 miles up) and about 50 miles high. The idea is to track by radar the behaviour of a "cloud" made up of strips of aluminium foil (or "window") which will float down to earth after being ejected from the rocket. In fact, two sets of cloud are proposed per flight, one to be watched from 30 miles down, the other to be tracked down to 30 miles from about 50. A standard gun-laying anti-aircraft radar set, modified for a range of 55 miles is to be used.

The sodium experiment of **The Queen's University of Belfast group,** under Prof. Bates, becomes effective at heights above 50 miles; it therefore enables measurements to be made at heights largely unexplored in this respect. In this way the results of these three experiments support each other well.

The lower level of Prof. Bates' experiment is in the region of 50 miles high; its ceiling is the ceiling of the rocket. This experiment has recently been staged in the States from an *Aerobee*; it entirely fulfilled its promise.

It depends for its functioning on the fact that there is a small amount of atomic sodium in the upper atmosphere (about a ton altogether, less than enough in a cubic mile to cover a pinhead); the luminescence from this is a constituent of the faint luminescence known as night airglow. Although one of the objects of the experiment is further to analyse the nature of this airglow, its greatest value in the *Skylark* research is as a tracer. From an artificially induced sodium glow, winds at great height can be observed, and by using spectroscopic means to measure line-widths, the temperature deduced. The cameras developed for use with the University College grenade experiment will be used for this experiment too.

We are familiar with the luminescent properties of sodium in the garish yellow of much modern street-lighting. The idea of conveying additional sodium to heights above 50 miles and thereby lighting a sodium vapour-lamp in the sky has a classical neatness. But it is a difficult experiment to carry out in practice. At ordinary temperatures sodium is a solid. To eject it from a rocket in atomic form it must be heated so that it boils vigorously (this is achieved now by mixing it with thermite and ignition of the mixture takes place within a canister on ejection). Moreover, the vapour must be dispersed through a very large volume for otherwise the luminosity produced would be too faint.

Potassium could be used to produce a similar artificial glowing "cloud", and this may be done in later stages of the *Skylark* work. The resulting fluorescence would then be red instead of yellow.

Skylark: Ionisation Experiments

The other experiment designed by the **Belfast group** will give direct readings of the intensity of light from the night airglow as a function of height. Certain spectral wavelength ranges for study will be selected by suitable filters, and the light-intensity will be measured electrically. These readings will be transmitted to the ground during flight as a coded radio signal.

A number of experiments have been devised to study the ionisation of the atmospheric components in the D and E layers of the ionosphere (60 miles up) and in the two F layers (above 100 miles).

The **University College** research will be directed to distinguishing between and to recording of the relative volume of electrons and negatively charged particles at selected heights, using detectors in conjunction with spectrometric techniques. This group will also try to determine the actual elements present at the operating height. One of the ambiguities that has arisen in previous rocket work on ionisation is the degree of disturbance caused by the passage of the rocket itself. The University College group hopes to circumvent this difficulty by projecting their apparatus out beyond the rocket's nose on a kind of proboscis. This is one of the reasons why *Skylark*'s nose cone is jettisonable once the rocket no longer encounters the aerodynamic heating of the lower atmosphere.

Experiments directed to gaining information on ion density are to be performed by the **Swansea group,** under Dr Beynon, but using radio probes to obtain the data. A difficulty encountered in obtaining ionospheric data from the ground-based radio-probes in use is that no measurement is possible *between* the reflecting layers of the ionosphere (since the reflecting properties of these alone enable the signal to travel back to the instrument for registration). Another point is that ionospheric recorders can only plot ion-density against *apparent* height (derived by extrapolation) not actual height. By in effect placing a mobile radio station in the sky which will pass signals to and from a ground station, Dr Beynon hopes both to plot ion density against

actual height and to obtain data on the ionisation of the region between the E and F layers.

The **Birmingham** ionospheric-sounding experiments (planned by Prof. Sayers) will be carried out in three stages: (*a*) measurement of free electron concentration as a function of altitude; (*b*) automatic mass spectrograph analysis of positive and negative ion species as a function of altitude; (*c*) investigation of positive and negative ion concentrations as a function of altitude.

For (*a*), use will be made of the fact that free electrons modify the dielectric constant of a medium, the free space dielectric constant being reduced by the presence of electrons. The local dielectric constant is continuously measured by a radio-frequency-probing electrode on the rocket, and from the results (transmitted by radio to the base station) the electron density may be calculated.

For (*b*) and (*c*), an automatic mass spectrometer will be ejected from the rocket, which will continuously sample the ions present in the ionosphere determining their various atomic or molecular types and whether they are positively or negatively charged. The information provided by the equipment will be coded in flight, reducing it to a form suitable for immediate radio transmission to the base station, where it will be recorded for detailed analysis.

Skylark: Summary

Similar upper-air measurements as are to be attempted from *Skylark* have been, and will continue to be made by U.S. scientists from rockets. But for any complete picture of the atmosphere's structure, observations at a number of bearings are required. The British effort will contribute readings up to 130 miles in a sub-tropical area in the Southern Hemisphere (central Australia) and in a temperate zone north of the Equator (Aberporth, Cardigan Bay). The techniques in some cases differ appreciably from those used by U.S. scientists.

The Americans have also staged rocket-borne ionisation experiments, but so far their efforts to identify the ions present have been inconclusive. Their most spectacular experiments on the chemical constituents of the upper atmosphere have been those conducted from *Aerobees* using fluorescent cloud-forming chemicals, which were performed at the suggestion of Prof. Bates, of Belfast. *Skylark* gives Prof. Bates the opportunity to conduct such experiments himself.

Russian Multi-Stage Rocket

Alternative methods for launching a satellite vehicle are discussed by the Chairman of the Astronautical Section of the Central Aero Club of the U.S.S.R., N. A. Varvarov, in the principal article of a recent number of *Science and Life*. This is a popular science magazine published by *Pravda*.

Instead of a three-stage rocket of the sort that the Americans are planning to use in their own *Vanguard* project during the International Geophysical Year, M. Varvarov suggests a multi-stage vehicle using turbojets and then ramjets. In the initial stages these "might have great advantages in economising fuel and would considerably simplify control".

He suggests two different ways of making use of such techniques. In the first, turbojet motors would be suspended beneath the large wings of a rocket vehicle and would take it upwards through the denser layers of the atmosphere to a height of 20 to 25 kilometres. The speed at this point is rather ambitiously put by M. Varvarov at "around 2000 kilometres/hour".

At this point, ramjets, "the most economical motors at supersonic speeds", would take over and the turbojets would be cast off. The ramjets would then take the vehicle up to a height of 35 to 40 kilometres and a speed of 5000 kilometres/hour. They would then, in turn, be cast off and liquid-fuel rocket motors, either single or multiple stage, would take over.

The second method suggested by M. Varvarov takes account of the fact that it would be undesirable from an economic point of view to jettison turbojet engines if this could be avoided. He therefore proposes that the rocket should be carried in an "aircraft accelerator" powered by ramjets that is, in turn, mounted on another, larger one, powered by turbojets. The heights and speeds aimed at for the first and second phases of the ascent are the same as those already proposed for the unmanned vehicle. He suggests that the second alternative would become particularly desirable later on when atomic motors become available. "These," he says, "will make possible the construction of an ISZ (artificial satellite) of considerably greater dimensions and weight, and when the conditions existing in the cosmic atmosphere have been studied in detail and also the possibilities of man's existence there, then inhabited artificial satellites will appear."

It is well known that the Russians have shown intense interest in ramjets and have tried to benefit from the work which Germans were doing in this field during the war as well as research carried out by others who voluntarily, in some cases, and involuntarily in others, worked in Russia after the capitulation. Nevertheless, the speeds and performances that have been postulated are larger than are likely to be realised at the present stage of technology.

Russia's Underwater Plans

The Russians are planning to anchor underwater scientific stations equipped with devices for automatically recording water temperatures, wave oscillations, and other data, at many points in the Pacific. This was announced at a recent conference on oceanographic methods at the U.S.S.R. Academy of Sciences. The Soviet research ship *Vityaz* will leave for the Pacific on July 1 for the first of five trips she will make in this ocean during the IGY. In this area the U.S.S.R., the U.S.A., Japan, and Canada are co-operating on research.

The *Ob* set off from Mirny in mid-January for her "autumn" oceanographic cruise off Antarctica. Her first investigation was of the vast Prydz Bay (where this year's Australian expedition at one time thought they would be obliged to open their second continental base since the approaches to the Vestfold Hills appeared blocked). The bay breaches the Antarctic perimeter deeply; it is also extremely deep, and this facilitates the access of warm ocean currents. The Russians found the water here at 3°C, though other measurements they had taken on the voyage invariably showed the water temperature below freezing-point. The consequence of this was that ice conditions made navigation much easier than off the nearby coasts. *Ob* was able to penetrate the ice to within a mile and a half of an ice-free archipelago from which the ice-sheet appeared to have receded quite recently; it is now 6·7 miles inland.

The bulk of the work to be done from the *Ob* off Antarctica this season will be related to drifting ice-floes. The cruise was to extend between latitudes 20° and 90° E. The *Ob* will be back off Mirny this month.

Schmidt Cameras Allocated

The positions of the twelve $60,000 Schmidt cameras specially designed by Dr James G. Baker, of the Smithsonian Astrophysical Observatory, for the precision observations of the U.S. earth satellites have now been settled.

They are being distributed on a "permanent loan" basis, and each one incorporates a crystal clock in its mechanism. Australia is to have one of the even more costly Mark I Minitrack precision radio-tracking installations as well as a special camera. Dr Lloyd Berkner, CSAGI reporter on satellites and rockets, congratulated Australia on being one of the few countries to take the initiative in such studies. Dr Berkner had been visiting the rocket range at Woomera, where both camera and Minitrack system will probably be established. The other countries to receive Schmidts are: Argentina (Córdoba), Peru (Arequipa), South Africa (Bloemfontein), Spain (Cadiz), Iran (Teheran), Hawaii, Japan, India, and the Dutch West Indies. Two will be set up in the United States, at White Sands proving-ground in New Mexica, and in Florida.

Second Reconnaissance of Bouvet

At the end of this Antarctic season the Russians are carrying out a ship and helicopter reconnaissance of Bouvet Island, the forbidding sub-Antarctic island which lies SSW of Cape Town and belongs to Norway. It was agreed at last August's Antarctic conference

that it was desirable to operate an IGY station on Bouvet. The Russians thereupon offered their services. If the Russians report favourably, a joint Soviet-Norwegian expedition may be established on Bouvet next season, probably from one of the Soviet Antarctic relief ships. This season's visit will be made from the ice-transport *Lena* (sister ship of the *Ob*) on her return voyage to the Soviet Union from the Antarctic.

Last season the South African naval frigate *Transvaal* sailed round the island and loosed off some salvoes from her four-inch guns to see if the ice that tops the island's precipitous cliffs dislodged easily. It didn't.

First All-Sky Photographs of *Aurora Australis*

On the first all-sky camera to be operated in the Antarctic, Dr Stanley Evans, of the Royal Society advance party, took these pictures of a developing display of the *aurora australis* at 75° 31' S. 26° 36' W. They are thought by experts to be among the finest photographs of the *aurora* at present in existence. The four frames selected show the progress of a display over a period of eight minutes from 1956 Aug. 26d 0025 GMT to 0033 GMT. The bands spread up and across the sky from low on the horizon of geomagnetic South (bottom of frames) to within a few degrees of the opposite horizon. Remnants of this period of activity littered the sky for many hours.

On the right of each frame the planet Mars can be clearly seen. Towards the south Canopus shows more faintly at about 40° elevation. The arc of light on the extreme edge of the frames (at about "seven o'clock") is due to the lights from the base-hut. On Frame 1. Dr Evans appears as a shadowy polar silhouette as he inspects his instrument.

A feature of these photographs and of all the displays observed at Halley Bay was the tendency to symmetry about the geomagnetic co-ordinates (geomagnetic South is roughly 20° off true South here). The base has proved to be ideally situated for observation of the southern auroral zone, whose position was only approximately known before. The zone is a narrow circular belt of diameter about 2500 miles centred on the magnetic axis point at 78·5° S. 111° W (as far as is accurately known). On this belt, which is just visible from Halley Bay, *aurorae* are almost always present. Any increase above the quiescent condition is at once observed by the northward extension of activity over the sky at the Base.

The programme of auroral studies at Halley Bay now comprises the photographic record from the all-sky camera, simultaneous visual observations at night, and a continuous 24-hour patrol by the radio-echo equipment designed at Jodrell Bank and dispatched last autumn with the Royal Society main party. By the time the IGY ends, Halley Bay should possess the most complete records of *aurora* ever kept within the auroral zone of either hemisphere; the day-and-night radar record having been augmented during darkness by the two further types of observation. Radar can also provide auroral data during stormy nights when displays are shrouded from the eye of observer and camera by clouds of drifting snow.

Information will be derived from correlating the three sets of observations at this base. Their value will gain enormously, however, from direct comparison with simultaneous observations made with paired equipments in the northern hemisphere; an all-sky camera is now operating at St Andrews, and an identical radar equipment to that in Antarctica is in use at Jodrell Bank. It will be surprising if this exhaustive study by the British does not eventually resolve some of the riddles posed by the *aurora*. In particular, it is hoped to discover whether the phenomenon is caused by magnetic disturbance in the upper atmosphere, or by actual particles thrown out by the Sun.

A description of the operation of the all-sky camera at Halley Bay was given in DISCOVERY, October 1956, p. 429. It is made in the United States and is automatic in operation. At regular intervals a 16-millimetre cine-camera photographs a mirror in which the whole sky is reflected, the exposure time fixed by the designers being one minute. Dr Evans succeeded in reducing the exposure to fifteen seconds, which gives greatly improved results for large, rapidly changing displays. Even so, the rays that spring up continually from the arcs during a display are not registered, as Dr Evans himself points out. He has suggested that his successor at Halley Bay cut the exposure even further, to five seconds.

Since the camera mechanism and

clock associated with it work out of doors, often at temperatures considerably below zero, such an easy command of a far-from-perfect development model is a great credit to the operator. Though several other all-sky cameras are now in polar regions, it seems that none has had comparable success.

Aurora Tropicalis

In its house magazine, the Cable and Wireless Company has published an article in Basic English on observing aurora at low latitudes. The magazine circulates to 130 stations and cable-ships in middle regions round the world. Basic English is the only common means of communicating with the staff of all these posts. Watchers for the *aurora tropicalis* are particularly wanted in the empty expanses of the great oceans; it is just in these places that cable and wireless stations thrive.

A "great Aurora" occurred on the night of January 21, but unfortunately was not visible in this country, as the night was overcast. Reports of the display, however, came from as far south as Portugal (where it caused some alarm in country districts). More recently, and quite unusually, fine displays have been seen in central districts of Australia.

Taking a Bomb To It

It seems we have not heard the last of the proposal put forward by Dr Keith Bullen, F.R.S., chairman of the Australian IGY committee and a distinguished seismologist, for studying the Earth's interior structure by means of atom bombs. A suggestion he put forward last summer for letting off an atom bomb in Antarctica as part of the IGY programme was turned down by CSAGI. There was no wish on the part of this body to be associated with a tool of such sinister reputation.

Just recently Dr Bullen made a public statement that shows that he has by no means abandoned the scheme. It was "something that must go forward later when conditions are favourable", he said. The project was for the explosion of three or four bombs: one off the Australian coast, one in Russia, one in an area to be chosen for the convenience of scientists making seismic records in America, and perhaps another in the centre of the Pacific.

The waves transmitted through the global crust from the point of impact would no doubt reveal a great deal about the composition and density of the intervening mass; seismologists would have the advantage of positioning something on the scale of an earthquake exactly where it would be of most use to their studies. But surely an experiment can be devised that will satisfy the seismologists and yet be less wholesale in its effects than the explosion of atom-bombs. Alternatively, would not those being let off in the course of national defence programmes do?

Rehearsals for "Moonwatchers"

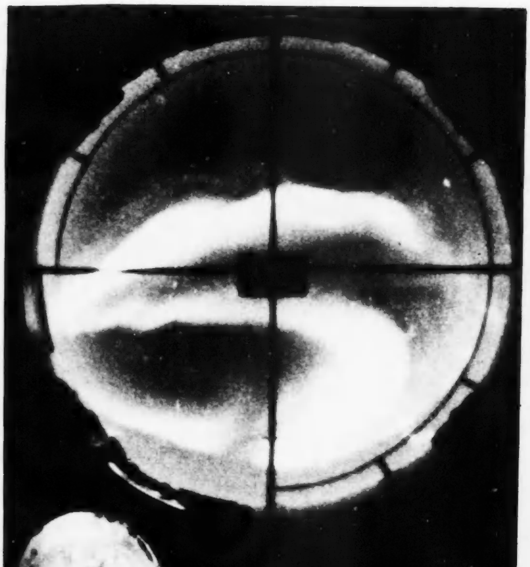
The first rehearsals during which high-flying U.S. Air Force jets would simulate the passage of an earth satellite are to take place any time from the beginning of May to test the efficacy of the teams of amateur astronomers which have volunteered to keep the satellite under observation once it is launched, the scheme known as "Moonwatch".

These "Flybys", as the Americans call them, are unusually realistic. High-flying aircraft will pass over the observing-stations at such altitudes that their engines will not be heard nor their navigational lights seen. Each plane will carry a light; this, seen from the ground, will match the apparent magnitude of a passing artificial satellite. The course and speed of the aircraft will closely follow the path and angular velocity of a satellite at a particular part of its orbit. Forty Moonwatch stations had registered by the beginning of this year a matter of 750 individuals.

Meantime, Dr Fred Whipple has urged Moonwatchers to keep a sharp look-out for the passage of one or more natural earth satellites. He maintains that it is quite possible that a meteorite may have been caught in an orbit and has passed undetected until now.

IGY Exhibition at Imperial Institute

"Antarctic Survey", the exhibition now showing at the Imperial Institute to illustrate the British Commonwealth's contribution to the IGY in South-polar regions, remains open until June 2 (Mondays to Fridays, 10–4.30; Saturdays, until 5 p.m.; Sundays, 2.30–6). The work of the Falkland Islands Dependencies Survey and of the Commonwealth Trans-Antarctic Expedition are featured.



LETTERS TO THE EDITOR

Congestion at Road Junctions

Sir:

The extent to which traffic is delayed is a serious problem. The long-term solution will require better and wider roads. Meantime, traffic congestion at certain junctions might be considerably reduced by a relatively simple change in the existing roads.

Consider the particular intersection shown in Fig. 1. ABC is a main road carrying considerable traffic. There are no traffic-lights and usually there is no policeman to direct the traffic. BD is a side road about 30 feet wide, and traffic must normally halt before entering the main road, ABC. About half the traffic coming in wishes to turn right; the other half, left. The traffic island T, and the white line TL, are central in the side road. This means that ordinarily there is not enough room between the pavement E and the traffic island T for two cars to draw up abreast. A car wishing to turn right may have to wait quite a long time before the traffic in *both* directions along ABC is clear enough; and this holds up a long queue of traffic in the side road, including cars which may only wish to turn left. There never is a blockage of traffic going into the side road towards D in the region from TF.

I suggest that the white line and traffic island be moved somewhat to the right so that they are roughly two-thirds of the way from E to F. This would now leave room for two lanes of traffic

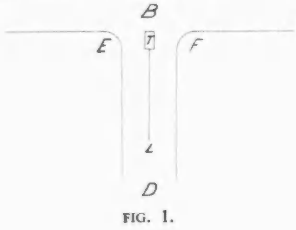


FIG. 1.

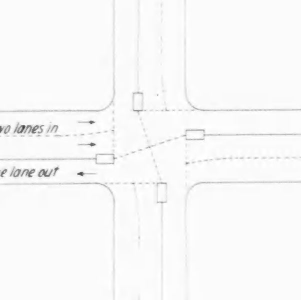


FIG. 2.

to draw up abreast with the head of the queue at ET. Traffic turning left need not be delayed by traffic wishing to turn right. So long as there is room for a single vehicle to pass between T and F there will still be no blockage of traffic moving into the side road. The result is that queue length and average waiting-time would be considerably reduced.

As a development of this idea, one might displace islands off-centre not only for T-junctions but where there are two roads that cross one another, as indicated in Fig. 2, provided that a proportion of the traffic is likely to be turning rather than going straight across. If the bulk of the traffic is always going straight across, then a much displaced traffic island on the far side of the intersection might cause a bottleneck there. This bottleneck would not be as bad as at the head of the queue at the entrance to the intersection, as vehicles with their different accelerations, spread out after moving off from a queue.

One might also look at this problem from an integral point of view. If there are ever queues of vehicles at an intersection they are queues waiting to enter the intersection; rarely ever queues waiting to get off the intersection. On this score it would appear that almost always it would be desirable (and certainly on average it would be desirable) to provide greater (relative or absolute) width of roadway so that there could be more than one lane of vehicles where the queues are, that is, at the entrances to the intersection.

For intersections where there are traffic-lights rather than unattended intersections, the gain I would think might be less per vehicle, as the waiting-time there depends primarily on the traffic-light time-cycles and not on the random occurrence of gaps in uncontrolled traffic streams.

Some experiments have been undertaken by the Ministry of Transport and Civil Aviation and the Road Research Laboratory on the movement of traffic at certain road junctions in London*†‡. Although these were junctions controlled by traffic-lights, two relevant points arise from the Reports: (*i*) A greater amount of traffic could move along the roads in question when the lane markings and pedestrian refuges were displaced from the central position in the road to an asymmetric position; (*ii*) the traffic flow in narrow traffic-lanes increased very sharply with small increases in the width of these lanes. A 20% increase was not unusual if a lane could be increased from 8 feet to 9 feet wide. The results of the traffic counts made by the Road Research Laboratory cannot be applied directly to intersections such as those discussed above for a number of reasons. The situations that were covered in some cases involved a number of roads all of quite different widths meeting at irregular angles. All the intersections were controlled by traffic-lights. There was considerable pedestrian traffic. There were unusually heavy and asymmetric turning components in the flow. There was a strong tidal component, as often occurs with city traffic going to and from work. In view, though, of the indications of improvement to traffic flow with small increases in lane width at queue heads, and the fact that there is not a proportionate reduction of flow because of the decreased width of roadway available leading off the junction, the Road Research Laboratory work would seem to confirm the likelihood of improvement in traffic flow if asymmetric lane arrangements were adopted for simple intersections without traffic-lights as discussed above. I would like to suggest that traffic counts be taken on a number of typical T, and cross-over junctions with temporary asymmetrical lane markings and traffic island positions, particularly as such intersections constitute the major part of all intersections in the road system of the country.

J. S. COURTNEY-PRATT.

Gonville and Caius College,
Cambridge.

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† "Traffic Flow past an Offset Pedestrian Refuge on Lambeth Bridge", J. A. Hillier and J. K. Smith, Road Research Laboratory, DSIR, 1953, Unpublished Note No. RN 2105 JAH.JKS.

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Nobel Prizes for the Young

Sir:

The leading Swedish newspaper, *Dagens Nyheter*, published only recently a short reference about an article apparently published in your monthly, regarding the Swedish Nobel Prize conditions.

If I am right, there is a very strong opinion also among Swedish scientists and other people here, exactly on the same lines as expressed in your article. According to tradition, the aim of the Nobel Prize was to spurt *young* scientists and young people who need such support not the very well-established and already accepted great names, but those young people who are fighting for their lives and need to earn their bread. Today some of the Swedish Academicians who decide about the prize-winners have replied to your criticism. I doubt whether there ever will be any change, because all of them are very afraid to do something not 100% secure. This is the neutrality of science (and there is also a very strict political policy).

HERMANN HERZ.

Angelholm, Sweden.

Swedish Comment

The Swedish newspaper *Dagens Nyheter*, of March 9, 1957, refers to the Editorial published in our March issue, p. 89, "Nobel Prizes for the Young?". A member of the panel

which awards the prizes comments: "It is true that the Nobel Prize winners as a rule have reached a venerable age, even though one can find a few young people among them." Prof. Arne Westgren, Secretary to the Royal Swedish Academy of Science, adds that of course it was regrettable that Einstein was not awarded the prize for his theory of relativity, but it is customary not to give the award for a theory, the validity of which cannot be judged. "As far as medical discoveries are concerned, some decades may pass before they can be practically applied," the President of the Karolinska Institutet, Dr Sten Friberg, points out. "It is in the nature of scientific research that years may pass before the importance of a discovery is realised—and during these years the scientist is growing old."

Prof. Westgren confirms the statement in DISCOVERY that, at the beginning, Nobel had not meant that the prizes should go to old and already internationally recognised scientists, but should be awarded to scientists who were on the verge of a big discovery.

In the first year that Prof. Westgren was Chairman of the Nobel Committee there were some protests against the choice of a winner—he was considered too old. The question was then asked whether there existed a reservation in the statutes against awarding the prize to a scientist whose discovery dated far back in time. This question was answered in the negative.

But Prof. Westgren agrees with DISCOVERY. "It would be desirable to award the Nobel Prize to more young scientists," he says. "And the Academy of Science really tries to find young, deserving scientists in order to award them the prize in their phase of active research. And young scientists are fairly well represented among the winners of the prize in Physics and Chemistry. The youngest winner hitherto was Lawrence Bragg, who together with his father, Sir William Bragg, won the prize in Physics (1915) at the age of twenty-five. It is, however, often difficult to estimate the capacity and scope of a young scientist, and an award, given without due consideration may prove to be a complete mistake.

"Already in 1905, Einstein presented the first and technical part of his theory of relativity, and in 1915 he published the later and general part of his theory. When in 1922 he was awarded the Nobel Prize it was 'for his services to Theoretical Physics and especially for his discovery of the law of the photo-electric effect'. *The importance was realised later.*"

Prof. Sten Friberg replies as follows to DISCOVERY's use of Fleming as an example of scientists who got the award too late: "It is true that Nobel intended the prizes to be awarded to young scientists. But he also talks about 'a scientific achievement'. Therefore, according to the statutes, the prize is awarded either for a definitely new discovery or for a discovery made earlier, the importance of which has not been realised before. Penicillin, as such, was nothing new, but the importance was not realised until the end of the Second World War. And the prize was awarded in 1945. Apart from that, a number of young scientists *have* been awarded the prize. Banting, who was awarded the prize jointly with Macleod 'for the discovery of insulin' in 1923, was only 32.

"Forssmann's heart-catherisation, on the other hand, made him a Nobel Prize winner almost a quarter of a century later, when science had made progress and two other scientists had worked out the practical application of his discovery. Forssmann made the discovery in 1929, and in 1956 he was awarded the prize jointly with his two colleagues.

"As far as a medical discovery is concerned, it is desirable that it should first have been tried out clinically," Prof. Friberg continues. "This does not preclude the possibility that sometimes when the prize-distributing committee are informed of a scientific achievement they may say at once: 'This is something really big: as, for instance, in the case of Banting's and Macleod's discovery of insulin.'

"Nowadays, the actual prize sum has not the same importance as it had at Nobel's time. The likely candidates usually have financial support from State authorities and from their universities. The real value of the prize has decreased. But the honour seems to remain unchanged."

HOW OLD IS THE UNIVERSE?

The Earth, it is now thought, may be approximately 3500 million years old. The whole system of several billion stars constituting the Milky Way galaxy—only one of millions in known creation—may be a billion years older. The greatest age that can be assigned to the universe itself, in its present form and content, is approximately 6000 million years. Such are the conclusions, from a variety of criteria, made by Dr E. J. Öpik, of Armagh Observatory, Northern Ireland, and published in the latest Annual Report of the Smithsonian Institution.

In reaching his conclusions Dr Öpik takes into account such factors as the amount of decay of such naturally radioactive elements as uranium and thorium, the rate at which the great star galaxies are receding from one another, and the average density of matter in space. From the average density, he estimates the amount of matter in creation. He concludes that if matter were distributed equally through all space the average density would be only 25 trillion billion billionths of a gram per cubic centimetre, and the space occupied by the Earth would contain only about 27 thousandths of a gram.

Actually, of course, much of this matter is concentrated in dense aggregations—stars and star systems like the Milky Way. Dr Öpik estimates that there is an average of twelve of these galaxies per cubic megaparsec of space—a megaparsec is 3·25 million light years (one light year is the distance traversed in a year by light at a speed of about 186,000 miles a second). For each galaxy in the universe, he calculates, there is a mass equal to about 2 trillion times the mass of the Sun. Of this mass, he says, the galaxies proper account for only about 10%, of the probable mass of the universe. The rest is dispersed in space between the galaxies.

In ascribing an upper limit of about 6 billion years to the whole universe, Dr Öpik means the beginning, not the present configurations, of the star systems of the state of matter out of which they are evolved. This can be considered as the time since creation of the present cosmos. Yet it may be, he says, that the universe is oscillating, expansion being followed by contraction and a return to the primitive state of matter. If this is the case, there have been many such cosmic structures in the past and there will be many more in the future. If so, our present universe is bound for inevitable death—eventual return to the highly condensed state of matter, pure nuclear highly condensed particles such as neutrons, electrons, and protons—out of which it evolved. Then another universe, far different from the present one, may evolve by much the same processes.

THE BOOKSHELF

Calder Hall; the story of Britain's First Atomic Power Station

By Kenneth Jay, with foreword by Sir Edwin Plowden (*London, Methuen, 1956, 88 pp.+16 plates, 5s.*)

When the Queen opened the Calder Hall atomic power station on October 17 last year she described the occasion as the beginning of a new era. For the first time in history nuclear energy had begun to make a substantial and continuous contribution to domestic power supplies. Since then, as the months go by and more and more encouraging reports come from the engineers who operate the station and from others who are designing successor stations for the various civil electricity authorities, it is becoming increasingly obvious that Calder-type reactors, based on natural uranium fuel interspersed in a honeycomb of graphite blocks and cooled by pressurised gas, have a great and long future ahead of them.

It is fitting, therefore, that there should be, in addition to the great welter of technical data on this subject, an official history in popular form which tells the story of how this power station came to be designed and built. Kenneth Jay, who has already set on record the early days and expansion of the Harwell research establishment and of the production factories in the north, has succeeded in producing a short account in a form and at a price that should guarantee a wide appeal. Its style is factual but easy to follow, well-balanced, and fair. It contains many excellent pictures and diagrams, and is suitable alike for adults and secondary school children. LEONARD BERTIN

Stonehenge

By R. J. C. Atkinson (*London, Hamish Hamilton, 1956, xv+210 pp., Figs. 8, Pls. XXV, 18s.*)

Stonehenge is the most singular monument surviving from prehistoric times anywhere in trans-Alpine Europe. It has been the subject of a vast amount of fantasy and ill-founded speculation, and the few informed studies that have been published are not easily accessible to the general inquirer. Mr Atkinson's book is particularly welcome on this score, for he provides a full and lucid description of the monument as it now stands, as well as an interpretation and discussion of every aspect that has been elucidated through the recent meticulous excavations carried out by himself and other specialists.

The contents of the book are well set out, and move from objective description of the monument to its sequence of construction, the techniques employed in erection, dressing, and transport, of the stone blocks, the identity of the builders, the inferences in cult and ritual that may be drawn, and finally on the place of Stonehenge in thought and speculation from medieval times to the present day.

It must suffice to say here that three main building phases can now be distinguished at Stonehenge, ranging from a late Neolithic sanctuary to the culmination, in an elaborate stone edifice, at the height of the Wessex Bronze Age; a time when this part of Britain enjoyed far-flung trade contacts with central Europe and the eastern Mediterranean. The monument has, of course, to be considered in relation to its geographical position, and the extraordinary number of burial-mounds, and other prehistoric earthworks, in its immediate neighbourhood, but the three most remarkable things about Stonehenge are probably the incorporation of spotted dolorite blocks brought from the Prescelly Hills in West Wales, the construction of the huge sarsen stone circle, and horse-shoe settings with their transverse blocks held in position by worked mortise and tenon technique, and thirdly, by the recent discovery of carvings of bronze axes and daggers on the surfaces of some of the sarsen uprights.

The recent excavations have confirmed that the Prescelly stones had been in different arrangements in earlier phases of the site's history. It was already known, from traces of tenon stumps and mortice sockets, that these stones had at some stage been incorporated in a structure with transverse blocks, or lintels, although in the final arrangement they were all used as uprights. The mortice and tenon technique, of course, recalls timber working in which its employment is more appropriate, and the question must remain open as to whether the stones already formed such a monument in West Wales, or were brought only as rough blocks to Salisbury Plain. The probability of timber prototypes is, however, fairly obvious.

Mr Atkinson has ventured on a discussion of the very difficult problem of the nature and routes of the transport of the Prescelly stones. If not altogether convincing, it is valuable if only to stimulate further study. It is generally agreed that water transport must have been chiefly used. Mr Atkinson supports the employment of rafts, and a shore-hugging route from Milford Haven to the Bristol Avon. The reviewer believes that sea-going boats were in use from before this period along the sea routes of Atlantic Europe, and that it would have been easier and safer to have sought the open sea. But these and other points are not essential to the main purpose of the book, which is thoroughly recommended, and without which no visit to Stonehenge should be contemplated. The text is well supported by line figures and photographs, although a certain dullness of finish in the latter suggest that the reproduction has not quite done justice to the originals.

T. G. E. POWELL

The Human Species

By Anthony Barnett (*London, Penguin Books, 1956, 351 pp., 5s.*)

It needs either great courage or great conceit to expound scientific knowledge for the layman. Every simplification and illustrative model which the writer uses—whether he compares atoms to billiards balls, or the nervous system to a telephone exchange, or food to locomotive fuel—carries with it a cloud of misleading implications. And even if he manages somehow or other to combine clarity with honesty, he must contrive in addition to be lively, provoking and enjoyable to read. Otherwise he will achieve nothing beyond deepening the layman's despondent feeling that scientists, when they are not dangerous lunatics, are dull dogs.

For these reasons the appearance in the Pelican series of Anthony Barnett's "The Human Species" is an immensely cheering event. For in this book honest and resourceful scientific writing, with the aid of brilliant pictorial illustration, gains an easy victory over the difficulties which I have mentioned.

The difficulties are in this case even more formidable than usual. Having set himself the task of discussing man and human society in the light of modern biological discovery, the writer is committed willy-nilly to navigating in the stormy seas of politics, morals, and religion. Yet Barnett deals fully and informatively with nature and nurture (including a section on Lamarck and Lysenko), with eugenics, with the facts of sex, with man's non-human ancestry, with race and racialism, with class differences and sex differences, and with problems of population growth and world poverty, in a style of cool and detached sagacity—as though he were scarcely aware that in each one of these fields he is a trespasser on the traditional preserves of superstition, prejudice, and passion.

This is an admirable achievement. The man in the street knows perfectly well that the method of science is powerful. He is reminded of its power every time he drives a car or looks at television. But he does not always know how much the progress of science has depended upon patience, reason, fair-mindedness, and tolerance, nor that every scientist worth his salt looks to a world in which these qualities, and the

power over nature which they can bring, become the common property of all mankind. DONALD MICHIE

The Hardiness of Plants

By J. Levitt (*New York, Academic Press Inc., 1956, 278 pp., 56s.*)

What might be termed the physiological plasticity of plants varies greatly from one kind of plant to another, even from variety to variety within the same species. From the human economic point of view the subject is of great importance in that the gardener, farmer, and forester need to know what are the extreme conditions under which a worth-while crop can be produced, whether a crop of a plant can be acclimatised or hardened, and whether hardier variants can be bred. The subject of "hardiness" is extremely complex and it is of great interest and use to have an up-to-date account brought together in a single volume. The extent of the literature, most of it dating from the last twenty or thirty years, is indicated by the fact that the references in the present work occupy over forty-four pages.

An attempt is made to define the terms "resistance" and "hardiness". The environmental resistance of a plant is taken to imply its ability to survive an unfavourable external environment, while hardiness is its ability to survive an unfavourable internal environment and is one specific aspect of the more general resistance. The author divides his matter into three main parts: low temperature hardiness, low moisture or drought hardiness, and high temperature hardiness. A very large number of experimental results and of hypotheses are critically discussed. One is impressed by the difficulties of obtaining satisfactory data and by the contradictory results that have been published, leading to a wide range of theories and generalisations. Most space is devoted to low temperature hardiness and the effects of freezing and cooling, frost injury, and the various factors that have been investigated in relation to frost hardiness. It is obvious that much remains to be learnt, but the following conclusions are reached. When freezing occurs inside the protoplasm, it always kills the cell. When freezing occurs outside the cell, in the intercellular spaces, injury may or may not result. Frost dehydration of the protoplasm leads to a progressive increase in protoplasmic consistency, until, with extreme dehydration, it actually becomes brittle. Damage may also be due to water removal from the cell as a whole when contraction subjects the protoplasm to tensions which may lead to death.

There are wide general comparisons made between frost and drought hardiness, and the author favours the view that both frost and drought injury are mechanical in nature owing to the dehydration of the cell. Evidence is produced to show that when plants become drought-hardy, due to a reduced water supply, they also become frost-hardy, and when they become frost-hardy, due to a low temperature exposure, they also become drought-hardy. Species and varietal hardiness to drought and frost may run parallel, and changes in hardiness with development are similar. Many of the same physiological changes occur during frost and drought hardening, while small cell size is correlated with both frost and drought hardiness.

The author holds that the hardiness of plants to frost and drought is essentially hardiness to dehydration. Dehydration, at a point, causes injury by enhancing the mechanical weakness of protoplasm and by stresses. Heat injury is conceived of as being due to the same mechanical weakness of the protoplasm which causes it to succumb to thermally induced oscillations. Thus while frost and drought injuries result, according to the views accepted in this book, by dehydration of the protoplasm, the action of heat is more direct. The common denominator for all the kinds of hardiness here discussed might be called protoplasmic cohesion, that is, the resistance of protein bonds to forces tending to break them and leading to unfolding and denaturation of the molecules. W. B. TURRILL

Marine Aquaria

By L. A. J. Jackman (*London, Cassell and Company Limited, 1957, 138 pp., 18s.*)

There has long been needed a sound modern book on the keeping of marine animals in small aquarium tanks. Since the days of P. H. Gosse and the latter half of last century (when, before the introduction of tropical freshwater fishes into the home, the marine aquarium was a popular object for the drawing-room) there has been no specialised book solely devoted to instruction in the art of the small marine aquarium. The need for such a book has for many years been amply demonstrated by the numerous letters received, by the Marine Biological Laboratory at Plymouth, from school teachers and others seeking practical advice on the subject. Such a book can only be completely satisfactory if written by someone who has had considerable experience with small tanks lacking a constant circulation of sea water supplied daily from the sea or from large reservoirs. Mr Jackman is well known in South Devon for his popular and most successful seashore aquarium and museum in an old building by Paignton harbour, and also for his recently built marine aquarium at Teignmouth. Whilst at both places he has sea water on his doorstep he none the less has kept many small marine fishes and invertebrates in tanks with infrequently changed water, and so after several years of experience he is well qualified to offer good advice. His advice is excellent and will smooth away many of the beginner's difficulties. He has original ideas on the construction of tanks and apparatus; having carried them out in practice, he knows they are sound. His remarks on methods of collecting specimens on the seashore and from deeper water are interesting; more so are his valuable hints on the feeding of a wide variety of species. There are some delightful notes on habits, which he himself has watched; and his short chapter on how to observe is good. He is not so good on morphology, and his descriptions of animal structure are here and there marred by unfortunate misconceptions, as when he describes the medusa of *Aurelia* in a manner applicable to a Siphonophore (tentacles as stinging polyps, mouth as a central feeding polyp, etc.). His spider crab is surely *Maia squinado*, not *Hyas araneus*. There are some misprints and a few minor errors. In another edition all these should be corrected. The book is illustrated by indifferent drawings; there are also a few half-tone photographs. One wonders why, when the publishers have reproduced two colour photographs on the dust jacket, they could not have repeated them as plates inside the book. D. P. WILSON

Die Technischen Anwendungen der Radioaktivität

By Engelbert Broda and Thomas Schonfeld (1. Chemische Institut der Universität Wien) (*VEB Verlag Technik, Berlin ; Porta-Verlag, München, 1956, 313 pp.+x, 19 D.M.*)

Atomic power holds the limelight in the development of peaceful uses of atomic energy. Its glamour commands popular attention; its promise loosens national and corporate purse-strings; its need is becoming urgent in many lands. Too often, though, we tend to forget that atomic power has a partner: nuclear radiation, an equally potent contributor to increased productivity and rising standards of living. Nuclear fission makes available radioactive isotopes (sources of high-energy radiation) in sufficient quantities, for the first time, to open up exciting new vistas in industry, agriculture, medicine, and biology.

The authors of this book on "the technical applications of radioactivity" have performed a valuable service in reviewing the rapid developments of recent years and, more importantly, in presenting this review in a concise and very readable manner. The material drawn upon is comprehensive and up-to-date: comprehensive not only in the extent of subjects discussed but also in regard to the world-wide coverage of some 1500 literature references cited; up-to-date in that it evaluates information first presented as recently as 1955 at the United Nations International Atomic Conference in Geneva.

This book is a general introduction to the subject. It stimulates further reading, thinking, and experimentation, and thus should be of greatest interest to

the technical worker as well as to the business executive. Even for the advanced nuclear chemist or physicist, its wealth of literature citations provides a useful source of reference material.

The first five chapters, comprising about a quarter of the book, review the basic principles of radioactivity, measurement techniques, and chemical methods of working with radioisotopes. Succeeding chapters describe technical applications of radioactivity in: Chemical Analysis; Mining, Smelting, and Metalworking; Chemical Industry; Electrical, Paper, Textile, Glass, Rubber, Plastics, Pharmaceutical, and Food industries; Agriculture, Forestry, and Hydrology.

Almost all the examples discussed in the foregoing chapters deal with the use of radioisotopes as tracers. On the other hand, chapter 11 covers applications of absorption and scattering of nuclear radiation to measure and control industrial processes. Chapter 12 discusses the use of massive doses of radiation to produce effects on matter. Among these are ionisation of gases to dissipate static electricity, excitation of luminescence, triggering of chemical reactions, sterilisation of foodstuffs and drugs, and pest control. Chapter 13 provides some general hints on health precautions required when radioactive materials are used.

The authors have adhered to the title of the book in the sense that, although radioactive sources are discussed fully, only two pages are devoted to electrical machines (such as Van de Graaff accelerators) as alternative sources of high-energy radiation. Within the context of chapter 12, in particular, one might wish for a more adequate discussion of the relative advantages and disadvantages of accelerators versus radioactive sources for irradiation purposes.

The industrial executive can find much in this book to stimulate his thinking on how to use nuclear radiation in his laboratories and plants. Nevertheless, he will miss any economic data relating to the cost of techniques described. From the layman's viewpoint particularly, the comparative scarcity of pictorial illustrations seems unfortunate.

These criticisms do not detract much from the value of the book for its stated purpose "to serve as a comprehensive introduction for the *technical* man". Inclusion of additional pertinent economic and visual material would give possible future editions an even wider appeal. MICHAEL MICHAELIS

Peru

By G. H. S. Bushnell (*London, Thames and Hudson, 1957, 207 pp., 71 photographs, 11 line drawings, and a map, 21s.*)

In spite of being packed with information, this book is far from indigestible, a fact which is due equally to the clear style and to the neat typography. Interesting problems are glimpsed, but remain tantalisingly unpursued: the relationship between certain Peruvian and Mexican cultures, for instance, and the puzzle of the strange patterns of lines and bird- and fish-forms found in the sands round Nazca, which cannot be seen properly except from the air.

One could have wished for less of a technological catalogue and more about the people who created the techniques. As a chronicle of skills and industries, rather than as a portrait of "Ancient Peoples and Places" (the book is the first in a series by that name), Dr Bushnell's text is excellent, and the illustrations are particularly well chosen to show the humour and plastic sense of these ancient Indians, whether they are elaborating abstract shapes, stylising natural ones, or creating life-like caricatures of their neighbours.

IRENE NICHOLSON

Microphotography: Photography at Extreme Resolution

By G. W. W. Stevens (*London, Chapman and Hall Ltd., 1957, 312 pp., 84 illustrations, 50s.*)

The making of microphotographs, that is to say photographic images of minute size, dates almost from the invention of the Daguerrotype itself and has had a somewhat curious history. The early efforts were mainly in the production of photographs of a pictorial nature or of pages of the Bible which were so small that they were objects of astonishment. This vogue, which lasted many years, is long over, but the production of very small photographic images of high resolution is used very much today for a variety of purposes.

Fifty years ago the processes by which these photographs were made were largely secret and each worker had his own special method. This naturally discouraged others from entering the field, and it is one branch of photography which has attracted relatively few workers. The position has changed radically since the commercial introduction of extreme resolution dry plates in 1940 and also since "micro" methods of photographic document copying have come to the fore. A great deal of work has been done in these fields and Dr G. W. W. Stevens is an acknowledged expert. His book, therefore, comes as a very welcome addition to photographic literature as it is perhaps the only book extant which deals with this highly specialised subject. Many scientists and photographers may think there will be little to interest them in a book of this kind but they will be much in error. The book contains a mass of very valuable information of great practical importance to anyone who has ever taken a photograph and who has had to consider, if only on rare occasions, the question of the photographic reproduction of fine detail in a small image. There are many references to the original literature which alone make the book of great value. Much of the book is of a practical nature and is very interesting reading, though the average reader will be in for some surprises when considering the finer points of image formation and recording.

It is a well produced and fully illustrated volume, and its acquisition is an obligation for all interested in serious photographic technique. It will probably remain a classic in its own field for many years to come.

R. MC. V. WESTON

Fundamental Study of the Nervous System

An interesting and exhaustive monograph written by Dr Humberto Fernandez-Moran, head of the "Instituto Venezolano de Neurología e Investigaciones Cerebrales", appears in the *Bol. Acad. Ciencias Fisicas Mat. y Nat.*, Caracas, 1953, vol. 16, pp. 3–153. Under the title "The Ultramicroscopic Organisation of the Interanular Segments of the Medulated Nerve Fibres of the Vertebrates", it expounds the work done by its author while at the Nobel Institute of Physics and the Institute of Cytology, Karolinska Institute, Stockholm. Electron-microscopy is used to study the peripheral nerve fibres of man, cat, rat, and frog. Methods of preparing and sectioning the nerve fibres are given in detail and excellent illustrations support the concepts in the text showing that the myelin covering is surrounded by a granular membrane of 200 A and that concentric rings from which small individual laminae emerge constitute the principal organisation of the myelin. In the axon cylinder a tridimensional net of filaments from 100–200 A in diameter, orientated either longitudinally or obliquely with granulous material in the net, was observed. This is connected to a fibrillar inner membrane of 200–300 A in thickness formed by a net of filaments like those of the neuro-axon. The work is profusely illustrated and represents a substantial step towards the understanding of the intimate nature of the axon cylinder. To summarize such a work is difficult and it ought to be read in its entirety by all those interested in fundamental studies of the nervous system.

J. TRUETA

Technology

The first issue of a new *Times* publication, *Technology*, appeared in March 1957. Edited by W. James, it contains articles on the training of apprentices in France, future electrical engineering, and the need for women to take up technological training. The chief aim of this new publication is "to provide a platform from which industries may declare their needs to the public, to Ministers, and to university professors, technical college heads, and schoolmasters and mistresses. In this way technology will seek to make plain what industry wants from the educational system and where it is dissatisfied." This policy is to be welcomed, and we wish it all success in the important task of using science to the utmost in industry.

Nauka i Zhizn (Science and Life)

This Russian magazine is described in the sub-title as "A Monthly Scientific-Popular Journal of the All-Union Society for the Dissemination of Political and Scientific Knowledge" (published by "Pravda"). The journal is in its 24th year. In general the scope is very similar to that of DISCOVERY. However, it is probably intended for a wider public, and is frankly nationalistic and propagandistic in its treatment of the subjects dealt with.

The contents of this number are: Leading article on the "Technical Creative Activity of the Millions" (i.e. the people); Section on "Achievements and Problems of Science": "The Periodic System and World Science" (to commemorate the 50th anniversary of Mendeleev's death); "On the Eve of the International Geophysical Year"; "Among the Ices of the Antarctic"; "Synthesis of Proteins"; "Atoms in the Protection of Health"; "Electrons and the Vacuum"; Section on "Science and Industry": Activities of the Academy of Agricultural Sciences; Section on "Institutes and Laboratories": "0·01 Natural Size" (=hydrotechnical models); Section on "Our Country": "Soviet Kazakhstan"; Section on "Science and Religion": "Lenin's Views on Religion"; "Life in the Universe" (i.e. on planets, etc.); "Prometheus will not be bound again" (against attempts to reconcile religion and science); other parts are devoted to "Scientific and Technical News"; "Future Prospects" (deviation of Russian rivers).

C. A. HOARE

Brief Notes

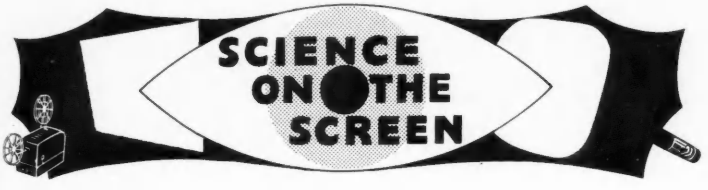
During 1957, 175 major scientific congresses will take place, on the average three a week. These are listed in the Twentieth List of "Forthcoming International Scientific and Technical Conferences" published by DSIR in January. The proliferation of science is exemplified by the subjects of the various conferences, ranging from the International Congress of Military Pharmacy, through the Sixth Conference of the International Society of Geographical Pathology, to the Technical Committee for the Prevention and Extinction of Fire! The compiler of this list is anxious to hear of further congresses which may have escaped his notice.

The Science Museum Library has brought out a new edition of their "Hand List of Short Titles of Current Periodicals in the Science Library", which, at a price of 12*s.* 6*d.* (H.M.S.O.), is well worth the money. No doubt a copy will find its way into every library of a research institute, since it is the most up-to-date source material of its kind. Twenty-two thousand sets of scientific and technical periodicals are now held in the Science Museum Library, of which 9500 are current; and they are being added to at the rate of about two new ones each day.

"New Biology", No. 22 (Penguin Books, 2*s.* 6*d.*), contains an article by J. B. S. Haldane on "The Prospects of Eugenics"; "How to Study Fossil Plants—Caytonia", by T. M. Harris; "The Life of the Lugworm", by G. P. Wells; "Stinging Capsules and Designing Nature", by L. E. R. Picken; "The Expression of the Emotions", by S. A. Barnett; "Blowfly Control in Australia", by G. R. Moule; and an article on Funaria by E. V. Watson.

The "Report of the Tin Research Institute for 1956" will interest chemists as well as metallurgists. It is available from the Institute's offices at Fraser Road, Perivale, Greenford, Middlesex, England.

DSIR's Bulletin No. 39, "The Strength Properties of Plywood, Influence of the Adhesive", is available from HMSO at 2*s.* 6*d.*



Song of the Clouds

A Shell Film. Director, John Armstrong. Producer, Stuart Legg. Cameraman, Edward van der Enden. Editing, A. Bailey. Colour. 35 and 16 mm. 36 minutes.

Every film can be judged on two grounds: firstly, whether it achieves what it set out to do, and, secondly, whether it succeeds also in being a good film.

There is no doubt in my mind that "Song of the Clouds" succeeds admirably in the first of these. It makes its audience conscious of the practical necessity for men to forget geographical and lingual boundaries; and even makes one forget for a moment the few publicised cases where colour and religion have not, unhappily, been discounted. Nevertheless, here is shown a practical demonstration of a true united nations at work, and the audience quickly realises that IATA (the International Air Transport Association) and ICAO (the International Civil Aviation Organisation) have achieved something to be proud of.

The complementary argument for air travel itself is not so successful. In stating all the "pros" the film has omitted all the "cons", and so has killed its own argument. There are no shots of a grey sky, of an anxious face, of an aircraft being talked down in a fog. It is a film of lyrical skies, of happy passengers all facing "the great adventure" in the same way with smiling expectancy, and of glorious vistas below the pretty fluffy white clouds. Personally when I fly I like to think that should the blue sky change to heavy cloud, I am still reasonably sure of reaching my destination, but there is no evidence in this film that that would happen.

Now to judge "Song of the Clouds" as a film. It is a strange mixture. It has been directed by John Armstrong with feeling and a light touch. If anything it is underplayed a little, lacking a deft hand with close-ups and contrasting angles, so that there is a "sameness" throughout the film. But the camera movements have been beautifully worked out, and the crowd shots nicely handled. The photography by Dutch cameraman Edward van der Enden is outstanding. The Eastman Colour is perfect, especially with the different skin tones and textures.

Unfortunately, this wonderful material has been made dull by muddled editing; in fact, the first five minutes of the film are so confusing that the whole of the airports sequence is quite meaningless, and starts the story off in a maze from which the audience is left to find its own way out. Furthermore the sound track, apart from the effects, is atrocious. "Mood music" has been scored as a background, and a commentary has been written that worries every action as a puppy worries a bone. The words underline heavily every point, they thump away at every natural sentiment. The supreme example of this is the sequence with Sita Desai and her baby. A natural sequence, quietly and easily directed; with just the two lines of commentary

> "Sleep well, Meera, in your cradle in the sky. Up ahead there are men on the flight deck listening to the unseen sounding beacons of the dark . . ."

it would have been perfect. But the point is pressed home so hard from then on, that the sequence loses purity, and becomes banal. Where the commentary is restrained it is very good, as in the shot of the child looking from the aircraft as it flies over the city:

> "Home is suddenly a toy town!"

I do not want to end this review with a feeling that "Song of the Clouds" is a failure. It is not that, it is a film well worth seeing, and even its mistakes are at least those of a Unit trying to achieve too much rather than too little.

SARAH ERULKAR

This is Automation

16 mm. 30 minutes. Colour. Produced by Ralph and G. Wolff for International Electric Company, U.S.A. Available from G.B. Film Library.

This film might be more appropriately described "Towards Automation". It concentrates almost exclusively on the factory floor, and upon the more filmable shots which are present among the transfer lines and metal-cutting operations of a typical industrial factory. I suppose one of the reasons why the metal-working factory floor has such a fascination for film directors is that it provides so many of what an American once described to me as "do funnies"—that is, interesting and ingenious pieces of mechanism which move in all directions at one and the same time.

One of the troubles about automation in its more advance forms—that is, in communication and control—is that it is very difficult to portray on a film except by diagrammatic and analogue methods. Opportunity exists for making a series of films on these subjects, hardly visiting the factory floor at all, but showing how automation is being applied in the many interesting fields in which control and communication play such an important part.

This is a well-made film; colour, attractiveness of shots, and verbal message are of a high order. The two important messages it seemed to leave were that: (1) automation can be applied to a wide variety of operations; (2) it is a technique which can be applied step by step.

Within the area of automation the film includes the following major groups: automatic handling, manufacturing, inspecting, assembly, testing, and packaging. The point is clearly and attractively made that many new techniques of automatic operation can be applied in each of these groups, and there are very many operations which can be up-graded with advantage. Unfortunately, examples which would appeal to the smaller firm are mostly left out. Anyone with a wide experience of industry will know that automation, or even advanced mechanisation, is not something for the large battalions only, but can be applied to every size of firm.

The film displays a few interesting diagrams. A particularly impressive one showed that if one divided up manufacturers' operations into three groups—manual, mechanisation, and automation—the average operation would be at the lower end of the mechanisation scale; this shows how much more opportunity exists, and effort is needed, to shift the average nearer to automation standards.

Because so few people even in industry understand the trend of progress, it is still probably necessary for relatively elementary films of this nature to be made. They have great value, particularly if they are followed by a question-and-answer session. People should be made aware of the fact that it is more important to move towards automation than to talk about the complete automatic factory. In other words, despite the many advanced techniques being discussed, and in a few special cases being installed today, the sad fact remains that taking industry as a whole in this country, the average level of mechanisation is lamentably low, and for many years to come automation will be more a goal to seek than an objective likely to be reached.

WALTER PUCKEY

The Scientific Film Association had hoped to hold a public Conference on the subject of "Presenting Science to the Public through the Film and Television", but owing to lack of support this has had to be postponed. The subject is of vital importance if science is to be properly appreciated in this country, and we can only hope that a second attempt to hold this Conference will be better supported. Longer notice might be given to those interested.

FAR AND NEAR

New Fellows of the Royal Society

The following scientists have been elected Fellows of the Royal Society:

Adler, Saul, Professor of Parasitology in the Hebrew University. For researches on pathogenic protozoa and the diseases caused by them, especially visceral and cutaneous leishmaniasis.

Amoroso, Emmanuel Cipriana, Professor of Physiology in the University of London. For studies on reproduction in vertebrates.

Auerbach, Charlotte, Lecturer in Animal Genetics in the University of Edinburgh. For pioneering work on the chemical induction of mutations.

Batchelor, George Keith, Lecturer in Mathematics in the University of Cambridge. For contributions to the theory of turbulence and other branches of fluid mechanics.

Burcham, William Ernest, Oliver Lodge Professor of Physics in the University of Birmingham. For experimental work with particle accelerators, and particularly for investigations of alpha-particle emission from the excited states of light nuclei.

Dainton, Frederick Sydney, Professor of Physical Chemistry in the University of Leeds. For contributions to physical chemistry, and particularly his work on reaction kinetics, polymerisation processes, and radiation chemistry.

Danielli, James Frederic, Professor of Zoology in the University of London. For work in cellular biology, particularly on the nature of the cell surface and on the intracellular localisation of enzymes.

Hoyle, Fred, Lecturer in Mathematics in the University of Cambridge. For work on stellar constitution, on nuclear reactions in stars, and on cosmological theory.

Jones, John Kenyon Netherton, Professor of Chemistry in Queen's University, Kingston, Ontario. For structural studies of complex macromolecules and his investigations on the biosynthesis of simple sugars.

Lipson, Henry Solomon, Professor of Applied Physics and Director of the Laboratories in the Faculty of Technology, University of Manchester. For work on the crystal structure of inorganic compounds and metallic alloys, and development of computational methods in x-ray analysis.

McMichael, John, Professor of Medicine in the University of London. For contributions to medical knowledge, especially on the mechanisms of heart failure.

Martin, Sir Leslie Harold, c.b.e., Professor of Physics in the University of Melbourne and Chairman of the Australian Defence Research and Development Policy Committee. For work on the ionisation of gases by x-rays and on the angular distribution of alpha particles from nuclear reactions.

Mendel, Bruno, Professor of Pharmacology in the University of Amsterdam. For work on true and pseudo cholinesterase and on "ali-esterases".

Oakley, Cyril Leslie, Brotherton Professor of Bacteriology in the University of Leeds. For researches on the toxins of anaerobic bacteria of the genus *Clostridium*, and on the site of antibody production.

Pitt, Harry Raymond, Professor of Pure Mathematics in the University of Nottingham. For work on the theory of series, harmonic analysis, ergodic theory, and random processes.

Rose, Francis Leslie, o.b.e., Director of Research, Imperial Chemical Industries (Pharmaceuticals) Limited. For work in organic chemistry, particularly for his contribution to the synthesis of drugs such as Paludrine and Antrycide.

Professor Amoroso is the first West-Indian to be elected a Fellow of the Royal Society. This is a great triumph both personally and for his country. By working unofficially at night, he paid for his education, and studied in Ireland, Edinburgh, Germany, and also in Reading; he is now accepted as the international authority on the placenta. He holds the Chair of Veterinary Physiology at the Royal Veterinary College, London, and has published many outstanding papers in his subject. The photograph is reproduced by kind permission of the Ciba Foundation, and shows Professor Amoroso during the Foundation's Symposium on the "Ageing in Transient Tissues", of which he was the Chairman.

Smith, Ernest Lester, Research Biochemist, Glaxo Laboratories Limited. For researches on the chemistry and biochemistry of vitamins, especially for the isolation and crystallisation of vitamin B_{12}.

Smith, Sir (Frank) Ewart, Deputy Chairman and Technical Director, Imperial Chemical Industries Limited. For the application of a scientific mind and of scientific knowledge and methods to the design, development, and management of chemical manufacturing plant and processes.

Squire, Herbert Brian, Zaharoff Professor of Aeronautics in the University of London. For contributions to the solution of aerodynamical problems, both by theoretical and experimental work. His work includes investigations of stability of air flow, of heat flow, of profile drag, and of the aerodynamics of helicopter rotors.

Steward, Frederick Campion, Professor of Botany in Cornell University, Ithaca, U.S.A. For work on the mechanism of salt absorption, and on nitrogen metabolism in mature and meristematic plant tissues.

Stiles, Walter Stanley, o.b.e., Senior Principal Scientific Officer, Light Division, The National Physical Laboratory. For work on vision, particularly on the physical and physiological processes concerned in stimulation of the retina by light.

Sutcliffe, Reginald Cockcroft, o.b.e., Deputy Director (Research), The Meteorological Office. For investigations in meteorology, which have put the problem of forecasting on a more scientific basis, by taking account of simultaneous dynamical processes and thermal changes.

Wadia, Darashaw Nosherwan, Director, Raw Materials Division, The Department of Atomic Energy of India. For researches into the geological structure of the Himalaya.

Watt, Alexander Stuart, Lecturer in Botany in the University of Cambridge. For contributions to ecology, especially of the cyclic changes in vegetation and soils.

Whittard, Walter Frederick, Chaning Wills Professor of Geology in the University of Bristol. For contributions to palaeozoic stratigraphy and to palaeontology.

Anniversary of Linnaeus: 250th Birthday

In Sweden a big scientific symposium, an enlarged graduation ceremony, the unveiling of a statue, a botanical excursion, three big jubilee festivals in different places, and four biographical works will this summer mark the occasion of the 250th Anniversary of the birth of Linnaeus.

The written invitation to the ceremonies include essays on Linnaeus's system of plant diseases and his plant geography, as well as the Transactions of the Swedish Society of Sciences from the very time when Linnaeus was the Secretary of this Society, and an analysis of preserved zoological samples in Linnaeus's collections. The university will publish a special volume of Linnaeus's autobiographies, edited and commented on by Bishop Malmeström and Dr. Uggla. (Linnaeus wrote four autobiographies which reveal the changes in the author's opinion of himself and his work through the years.)

In the Symposium scientists from ten different countries will take part and representatives of several foreign Linnean Societies are expected, among those, above all, representatives of the Linnean Society in Great Britain.

In London, the Linnean Society will mark the occasion by giving a reception in the evening of May 30. There will be on view interesting examples of the books and manuscripts of Linnaeus from the Society's collections, and a selection from his botanical and zoological collections. During the evening three short lectures will be given on the background to Linnaeus's life.

Endeavour Prizes

As a contribution to the meeting of the British Association for the Advancement of Science to be held in Dublin on September 4 to 11, 1957, Imperial Chemical Industries Limited, publishers of the quarterly scientific review *Endeavour*, have offered the sum of 100 guineas to be awarded as prizes for essays submitted on a scientific subject. As the primary purpose of these awards is to stimulate younger scientists to take an interest in the work of the British Association and to raise the literary standard of scientific writing, the competition is restricted to those whose twenty-fifth birthday falls on or after June 1, 1957. There will be a first prize of 50 guineas, a second prize of 25 guineas, a third prize of 15 guineas, and two special prizes of 5 guineas for competitors who have not passed their eighteenth birthday on June 1, 1957.

The subjects for the essays are as follows: (1) The International Geophysical Year; (2) Science Fiction; (3) Irish Contributions to Science; (4) Atmospheric Pollution; (5) Chemistry and the Conquest of Disease; (6) Particles in Plant and Animal Cells. The essays, which must be in English and typewritten, should not exceed 4000 words in length, and only one entry is permitted from each competitor. All entries should be addressed to: The Assistant Secretary, British Association for the Advancement of Science, Piccadilly, London, W.1, and the envelope should be clearly marked "*Endeavour* Prize Essay". The latest date for receipt of entries is June 1, 1957. The essays must be submitted without signature. The competitor's full name and address and date of birth should be disclosed in a sealed covering letter attached to the essay and addressed to the Assistant Secretary of the British Association, who will acknowledge all entries.

In judging the essays special attention will be paid to the originality of the approach to the subject, and great importance will be attached to literary style.

Fishery Scientists Plan Meeting in Lisbon

A joint scientific meeting of fishery scientists has been planned by the International Commission for the North Atlantic Fisheries, the International Council for the Exploration of the Sea, and the Food and Agricultural Organisation, and will take place in Lisbon from May 27 to June 3 this year. It is expected that more than fifty scientific papers dealing with the effects of fishing, fishing effort and selection in fishing will be presented. Scientists from at least fifteen different countries will participate.

Post-graduate Course in Nuclear Power

In October 1957 the Imperial College of Science and Technology will offer, for the first time, a year's full-time post-graduate course of instruction in nuclear power. The course will be administered by the Department of Mechanical Engineering under the general supervision of the Professor of Nuclear Power in association with the Departments of Physics, Metallurgy, Electrical Engineering, Civil Engineering and Chemical Engineering.

The arrangements for the course will be based on the belief that nuclear power is not a distinct technology, but a new field of application for the existing basic branches of engineering and applied science.

To meet the needs of students who have graduated in different basic branches of engineering, it is intended that the post-graduate course should be divided into two groups of lectures, a group of back-bone lecture courses, and an approved selection of optional lecture courses. In addition there will be a certain amount of practical work.

The Nuclear Power course is intended for students holding a good honours degree in Mechanical, Chemical, Civil and Electrical Engineering, and is a full-time course of one year. The fee for the full course is £64 for the session of three terms. Candidates may also be considered for one or more of the optional lecture courses at *pro rata* rates. Satisfactory completion of the course will qualify for the award of the Diploma of the Imperial College (D.I.C.).

Applications for admission to the course should be made as soon as possible, and not later than July 1, on a form obtainable from the Registrar, Imperial College, London, S.W.7.

Floating Ethnographic Laboratory

The *Centre National de la Recherche Scientifique*, the French DSIR, has recently commissioned a small vessel about 30 ft. long and 10 ft. wide, exclusively destined to serve anthropological research work. It is fitted with two diesel engines of 15 h.p. each, and air-conditioning plant. Under the direction of Prof. M. Biaule, it has made a trial run on the Niger River, and a second cruise in October 1956 on the same river.

The boat has three cabins for scientists to live in, one sound-recording studio with two tape recorders, a wireless station, one laboratory for photographic work, and special storage facilities for the collection of anthropological artefacts as well as of biological and archaeological specimens. For the year 1957, voyages up the Niger River area, up to Gao, on the southern border of the Sahara, are planned.

"André Mayer Fellowships"

The Director-General of the Food and Agriculture Organisation (FAO) has announced the award of the first André Mayer Fellowships. The recipients are: K. L. Kinsman, of Australia, whose field is the study of statistical methods of evaluating long-term trends in demand; A. G. Wurtz, of France, who will study the ecology of fresh-water ponds; A. Sumihiko, of Japan, who will study forest tree seeds; Bastos de Macedo, of Portugal, studying the mechanics of the retention of phosphorus through pure minerals and through clays of soils; and P. M. Lagervall, of Sweden, whose subject is population genetics applied to animal breeding.

The research fellowships were named after Prof. André Mayer, of France, who died in May of 1956 after a long and illustrious scientific career. Honoured both in his own country and on the international scientific scene, Prof. Mayer was one of the moving spirits in the formation of FAO, and closely associated with its development and its governing bodies.

Scholarships Abroad

Over 100 scholarships are being offered to British students by seventeen foreign countries for study abroad during the academic year 1957–8. They are mainly for university graduates and undergraduates, but some are open to candidates with non-academic qualifications. The scholarships generally provide for free tuition and maintenance, and most of them are tenable for a full academic year, though there are a number of awards for shorter periods. The British Council assists in publicising the offers and in most cases in the recruitment of candidates. Further information and application forms, for which a stamped, addressed foolscap envelope should be sent, can be obtained from any British Council office, or from the Controller, Education Division, The British Council, 65 Davies Street, London, W.1.

Ship Hit by Meteorite

A ship of the Black Sea Merchant Fleet, the *Izmail*, sent a radio message to the U.S.S.R. Ministry of the Merchant Navy stating that she was struck by a meteorite on the night of January 29, at a distance of about 100 miles from the island of Sokotra in the Indian Ocean, while on her way to Odessa from Calcutta.

There was a blinding flash of light as the meteorite struck the foremast. The crew later found on the deck a fragment measuring about one inch by one and a half inches and weighing just over three-fifths of an ounce. No damage was done to the ship.

Science Lectures for Canadian Children

In 1956 the first Christmas Lecture for children was organised by the Science Association of Canada. Although similar Christmas Lectures on Science have been a tradition in England ever since the days of Michael Faraday, the lecture on "The Fun of Physics", given on December 26, 1956, by Dr D. K. C. MacDonald, was the first of its kind in Canada. Dr MacDonald, who is head of the low-temperature and solid-state physics group, held his overflow audience spellbound ("not a creature was stirring"!) by demonstrations, models, and slides illustrating some of the basic problems of physics, especially such concepts as "order", "disorder", and "irreversibility".

The second lecture in this series, entitled, "The World Through Artists' Eyes", was given by Alan Jarvis, the Director of the National Gallery of Canada. Mr Jarvis explored the "real" world of science, the inner world of feeling, and the magic world of imagination and fantasy. By means of a make-believe camera view-finder, Mr Jarvis showed how the artist scanned the everyday world in search of beauty and delight. Using "chalk talk", he explained the scientific basis of such concepts in art as "expression", "composition", and "form". He introduced his audience to the values of abstract art, first by pointing out the abstract elements in children's paintings, and then by showing two experimental films of animated abstractions by Norman McLaren, of Canada's National Film Board.

The Metrovick 950

As one of the pioneers in electronics the Metropolitan-Vickers Electrical Company has for some years been engaged on basic developments for a variety of electronic computers, and has recently announced the completed development of the first model of a proposed range. The new unit, called the "Metrovick 950", is a general-purpose model capable of application to a wide variety of mathematical problems in research and engineering design. The first "950", completed some months ago, is now in experimental use in the Company's Electronics Department. The design of this computer incorporates interesting features of modern technique, of which two in particular are worth special mention: first, the use of printed wiring on the plug-in boards; and second, the extensive use of transistors instead of thermionic valves.

"Volcanic" Power Stations

The famous power station of Larderello, in Tuscany, is the only one in the world which is using the earth's own heat. Powerful jets of steam gush up from the bowels of the earth, the so-called geysers. Foreign scientists have described this region as one of the circles in Dante's Inferno transformed into a prodigious source of new power.

The geysers, and spouts which are obtained by the perforation of the earth's crust produce more than 200,000 kilogrammes of steam per hour, with a maximum as high as 300,000 kilogrammes, at a jet of more than 500 metres per second. The Larderello Power Station today produces 290,000 kilowatts. The heat of the earth provides 10% of Italy's total consumption of electricity.

In the last few years on plans drafted by Italian technicians an attempt has been made also to harness the endogenous power of the Campi Flegrei. Drilling has been effected, using the method of electric prospecting for underground sounding. In the deepest sounding, at 1200 metres, a temperature of 330°C was registered. The soundings, however, have been unable to penetrate the layers of volcanic ash, which by various chemical phenomena assisted by the high temperature and pressure, have been transformed into masses of kaolin. The jets of steam which form the geysers cannot penetrate this impermeable rock. The attempts are, however, continuing.

Similar experiments are being made in Japan, New Zealand, Iceland, and in the great valley of 10,000 fumaroles in Alaska.

Unusual Task for Radio-isotopes

The Japanese are finding a unique use for radio-isotopes. In ancient temples where bulky x-ray equipment cannot be accommodated, the radiation from cobalt-60 or some other suitable radio-isotope is used to obtain x-ray type photographs of the works of old sculptors. These figures, usually of cast bronze, are reinforced with sticks and rods. Each artist has his own way of reinforcing the figure. The photos made with radio-isotopes have not only identified the creators of some important works but have also provided accurate reference information and detected cracks and flaws needing repair.

Retracing Darwin's Voyage

A group of scientists has announced plans for retracing the five-year sea voyage made by Darwin which helped him formulate his theory of evolution. The new voyage is scheduled for 1958. Dr Julian Huxley, and Lady Nora Barlow—a descendant of Darwin—are co-chairmen of the project. The year 1958 was chosen for the voyage because it marks the centennial of Darwin's presentation of his historic theory on evolution to the Linnaean Society in London. Actually, Darwin's journey was made between 1831 and 1836. Darwin sailed as the official naturalist on the British survey ship *Beagle*. The expedition visited islands in the Atlantic, the coast of South America and adjacent islands, and islands of the western Pacific. Darwin studied the people and the flora and fauna of the areas. After his return, he wrote his "Origin of Species".

Dr Huxley said that twenty men and women scientists will be chosen for the memorial voyage and that others will probably be flown to the sites to be visited. October 1958 has been tentatively selected as the month for sailing.

Inventions for Industry Limited

Inventions for Industry Ltd has been set up to assist the inventor to place his work and to secure the most advantageous terms. Its four directors include two inventors, one in the field of electronics and photographic techniques whose inventions are being exploited by some very large concerns, the other a chemical and chemical engineering consultant, with a successful record in industry.

The organisation will act as agents for inventors in the placing of their inventions and negotiating the terms on which the inventions may be developed and marketed. It is proposed to concentrate at any one time only on a small number of inventions, so that each may be given the attention it requires. The Company is not seeking to be flooded with undeveloped ideas or gadgets: its concern is to limit its initial operations to inventions or processes having serious and important industrial application. The Company also offers manufacturers advice about inventors and inventions in fields in which a firm may have particular problems. It will not charge inventors any registration fee and will ordinarily aim to finance its operations out of an agreed percentage of the payments received by the inventor.

Ice-free Shipping Lanes

A method for freeing shipping lanes of ice during winter months, which has been tested over the past few years in Sweden, has proved so successful that a large-scale project is now being considered to ensure an ice-free passage between the port of Västeras, on Lake Mälar, and Södertälje, on the Baltic. The system consists in laying perforated plastic tubes on the bottom of the waterway. Compressed air pumped through the tubes escapes through the holes, whirling the warmer water up to the surface and thus melting the ice. The constant movement of the water prevents further ice formation. Experiments have proved that the project would be a paying proposition, eliminating costly ice-breaking and allowing normal merchant shipping traffic.

Shipping on Lake Mälar, one of Sweden's busiest inland water courses, has hitherto been greatly hampered by protracted and heavy ice formation in winter. The lake is deep and relatively free from strong currents, and would thus be well suited to the installation of the compressed-air system.

FAR AND NEAR—continued

Desalting Sea Water

The largest plant in the world to purify salt water electrically is ready to go on stream at Bahrain in the Persian Gulf.

The Bahrain Petroleum Company Ltd is installing the plant to produce 86,400 gallons per day of fresh water to supply the drinking and cooking water needs of a community of about 5000 persons centred in Awali near the Bapco refinery. The desalting plant was manufactured by Ionics Inc., a Massachusetts firm which developed the desalting apparatus from its basic knowledge of ion exchange and ion transfer.

The plant takes advantage of the fact that the molecules of salts and minerals when dissolved in water break into two parts, or ions, one with a positive and one with a negative electric charge. Water molecules, however, remain tightly locked in combination without electric charge. A direct electrical current forces the negative ions in one direction and the positive ions in the opposite direction. No effective separation takes place, however, unless the salt ions can be trapped, since the ions will recombine as soon as the electric current is stopped. If, however, the ions can be trapped into ion-tight compartments, then desalted water results.

Ionics achieved this permanent separation of salt and water by developing a series of water-tight membranes that would pass either positive or negative ions, but not both. By arranging the membranes alternately, every other compartment in the desalter becomes increasingly free of salt, while a heavy build-up takes place in neighbouring compartments. In this plant, the fresh water comes from the even-numbered compartments, while a heavy brine is pumped continuously from the odd-numbered compartments, thus carrying away the salts and minerals removed.

Award to German Engineer

The Council of the Institution of Mechanical Engineers have awarded the 1957 James Watt International Medal to Prof. Dr Ing. Walther Bauersfeld, of Zeiss-Werke, Germany, in recognition of his work as a scientist, inventor, and successful organiser, particularly in the application of precision engineering in the field of optics. Prof. Bauersfeld will come to London in May to receive the medal at the Institution, and will deliver a lecture.

Stanford Research Institute in Zurich

Stanford Research Institute will shortly open a European Office in Zurich, Switzerland. A principal aim of the office will be to establish a two-way flow of information between European and American industrial and research organisations seeking new research production, or marketing relationships.

The Swiss location will provide a base for SRI research teams assigned to Western Europe. Another function is the development of exchange and fellowship programmes between U.S. and Western Europe organisations.

Airborne Reactor

The U.S. Air Force's converted Convair bomber made its first test flight carrying a reactor last August. The reactor does not actually power the super-bomber; it is turned on only at very high altitudes over unpopulated areas. The USAF said the reactor is useful in testing methods of shielding the crew, reactor operators and electronic equipment against radioactivity under flight conditions. New types of nuclear instrumentation are also checked while the reactor is in operation.

A Flora of Central Africa

The Governments of Portugal, the Federation of Rhodesia and Nyasaland, and the United Kingdom are collaborating in the preparation of a Flora of Central Africa to cover Mozambique, the Rhodesias, Nyasaland, and Bechuanaland. The direction of the project has been entrusted to a Managing Committee, which is holding its first meeting at Kew on October 12 under the chairmanship of Dr G. Taylor.

Classified Advertisements

OFFICIAL APPOINTMENTS

MINISTRY OF LABOUR AND NATIONAL SERVICE. H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts in the Factory Inspectorate which is being expanded. Age at least 21 and normally under 30 on June 1st in the year of application. Extension of the upper age limit for regular service in H.M. Forces and for candidates with exceptional qualifications. Starting salary £545 (at age 21) up to £710 at 26 or over. Scale maximum £980. Somewhat lower outside London. A special increment of £25, within the scale, is granted after satisfactory probation. Higher posts filled by promotion from Class II.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health and welfare of work-people and extend to all manufacturing industries and to certain other places, including Docks, Works of Engineering Construction and Building Operations.

Candidates should normally have a university degree (which may be in science or in arts subjects) or have technical qualifications of comparable standard (e.g. A.M.I.Mech.E.). Experience in works or other practical spheres is an advantage.

Candidates without degrees or similar technical qualifications will be considered if they have had extensive works or other practical industrial experience (especially in responsible positions) and if they have good general or technical qualifications.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280/15.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects, and (*e*) Miscellaneous (including e.g. Geology, Library, and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer. Minimum £925 (women £853); Men's scale maximum £1135.

Assistant Experimental Officer. Starting pay £365 (at 18) up to £655 (women £632) at 26; Men's scale maximum £805. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects.

Opportunities for further education.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

Interview Boards arranged at intervals, as required. Early application is advised.

APPLICATIONS are invited for pensionable posts as

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to undertake the official scientific, technical, and legal work in connexion with Patent applications.

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Candidates must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally candidates otherwise qualified by high professional attainments will be considered.

Starting pay for five-day week of 42 hours in London between £605 and £1120 (men) according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review) and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S 128/57 and stating date of birth.

Interview Boards will sit at intervals, as required. Early application is advised.

SLEEPING SICKNESS CONTROL OFFICER required by NORTHERN NIGERIA GOVERNMENT Medical Department for one tour 12/24 months in first instance. Salary scale (including inducement addition) £810 rising to £1386 a year. Gratuity at rate £100/£150 a year. Commencing salary according to experience. Clothing and touring equipment allowance £85. Free passages for officer and wife. Assistance towards children's passages and grant up to £288 annually. Liberal leave on full salary. Candidates, preferably single, should have good general education and agricultural training or knowledge of surveying, mapping, entomology, or botany. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M3A/43728/DI.

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